Engineering Record

A Weekly Journal Devoted to Civil Engineering and Contracting
PUBLISHED BY MCGRAW PUBLISHING COMPANY, INC.

Volume 70 NEW YORK, SATURDAY, SEPTEMBER 5, 1914 Number 10

Time Saving by the Panama Route

A 50-PER CENT saving in the time of passage from San Francisco to New York was effected by the Panama Canal in the first trip of a vessel routed by the new waterway. The "Pleiades" sailed from San Francisco on July 27, stopped for a day in Los Angeles and was held four days at Balboa, at the western entrance of the canal, waiting for the waterway to open. She reached New York on Aug. 26, thus taking thirty-one days in all for the voyage, or twenty-six days actual traveling time. By the Magellan route the trip generally requires from sixty-two to sixty-five days and is attended, at the southern point of the trip, by unusual storm dangers. The voyage of the "Pleiades" signalizes a new era in the commercial relations between our two coasts. Simultaneously the event marks the beginning of better trade relations with the western coast of South America, now receiving much attention from American exporters.

Passenger-Rate Increases

FOLLOWING the advice of the Interstate Commerce Commission—to secure additional revenue from sources other than freight business—several of the railroads have raised passenger rates. The Pennsylvania applies the increase to mileage books only, the rate per mile going from 2 to 2¼ cents. This action emphasizes again the straits in which the railroads find themselves. Only as a last resort would they do anything liable to antagonize the public. Already there has been criticism of the curtailment in service, but the railroads now have no other course. Twice, in the case of the Eastern roads, at least, the Interstate Commerce Commission has refused the request of the lines for the privilege of charging higher freight rates. In the end, of course, the people at large must bear any increase in transportation costs, whether direct, as in passenger-rate advances, or concealed, as in higher freight rates. Direct taxes, it is axiomatic, are unpopular. The same psychology applies to passenger-rate advances, and expressions of dissatisfaction can, therefore, be expected from the traveling public. Nevertheless, additional revenue is a vital necessity for the railroads at present, and the public's criticism is probably the less of the alternative evils. The action of the lines may serve, too, to bring the people to a keener realization of the plight of the railroads. If that be accomplished, the rate advance may be a benefit for reasons other than financial. If railroad badgering is discountenanced by the public at large, a change in the attitude of Congress and of the Interstate Commerce Commission is to be expected.

Irrigation Difficulties

SINCE the difficulties into which our American irrigation enterprises fell some years ago there has been much discussion of their causes and remedies. While inadequate engineering investigations and dishonest financing can be blamed in some cases, it is fully agreed that the most important cause was the failure to evaluate correctly the human factor—the securing of properly qualified settlers, or the education of those not qualified. In the State of Victoria, Australia, it is believed that the salvation of irrigation enterprises lies in the extensive financial assistance accorded the settler by the Government. Not only are the terms of payment for the water made very easy, but money is loaned him for farm improvements and the purchase of equipment. While one would gather from the report of Elwood Mead (abstracted on page 220, issue of Aug. 22) that the method can even now be stamped as a success, there is reason for advising that final judgment be withheld. An extensive private enterprise in Canada proceeded upon the same basis, though even more liberally than the Victorian Government. With the greatest regret it must be recorded that the scheme across our border has not been a success. It is possible that Victorian conditions as to fertility are superior to those in Canada or here, and that may account for the apparent ability of the Victorian farmers to meet their obligations. In view, however, of the failure of the same method in Canada and of the clear demonstration in the United States that the man primarily is the factor and not the extent of his equipment or the weight of his obligations, it would be rash to declare in the present early stages of the Victorian experiment that it was so successful as to warrant its consideration for adoption in the United States. Certainly the plan is a most interesting one and deserves careful consideration. At present, however, it would seem advisable for us to assume an attitude of watchful waiting.

American Manufacturers Alert

HAVE American manufacturers risen to the opportunity offered them by South America's needs? Such is the natural question after a month's contemplation of the South American trade situation. The answer can best be given by stating that the Bureau of Foreign and Domestic Commerce and the custom houses throughout the country have been deluged with inquiries. In many parts of the country custom-house stocks of South American literature have been exhausted, and representatives of manufacturers gladly wait their turn to consult reference books on the subject. Furthermore, events at Washington are being followed so closely that no other interpretation can be placed upon the interest displayed than that manufacturers are willing and able to grasp the present opportunity. The ship-registry bill has not, of course, brought about immediately the shipping readjustment needed. Relief will not be found until the navigation laws are changed so as to allow operating economies fairly comparable with those of vessels flying foreign flags. The war-risk insurance bill passed the House by a vote of 230 to 58, and the amendments to the measure as adopted by the Senate are of such a nature that there is certainty of Senate concurrence and the early approval of the measure. There is reason for believing, too, that the President, provided private capital does not come forward, will insist upon the passage of a bill permitting the Government to buy merchantmen. The opposition to this measure is not strong and finds little sympathy from the country at large. There seems to be little doubt, therefore, that the shipping situation will be shortly straightened out and that American manufacturers who have been studying and planning for the last month upon export-trade extension will be able to make the shipments as quickly as orders can be secured in goodly amount. Manufacturers can proceed to develop trade, confident that transportation will be available as soon as required.

Britain's Designs on German Trade

REFERENCE was made in these columns last week to the optimistic tone of the British engineering journals with regard to the effect of the present war on British industrial life. The latest editions of "The Engineer" and "Engineering" to reach this country, dated Aug. 21, discussed the situation again at considerable length and—let it be distinctly noted by American manufacturers—point out to British citizens the opportunities for capturing Germany's trade, particularly with South America. We had been expecting here that the war would so engross England that her manufacturing establishments would be badly crippled, thus removing her, as well as Germany, from strenuous competition in the South American market. There is warrant, too, for the optimism of these English journals, for there seems to be no doubt that British domestic trade is keeping up very well indeed. That there is reason for optimism, however, in expecting any large raid upon German trade in South America can well be doubted, for even though manufacturers appear to be comparatively unhampered, money will certainly be tighter in England than here. While, therefore, we are not to expect complete elimination of British competition in South America, there is no danger that it will be so strenuous as to form any discouragement for American manufacturers who, since the outbreak of the war, have been planning extensions in South America. If anything, the British designs upon German trade should stimulate us to even greater efforts. The British Board of Trade is distributing monographs showing in what lines Germany and Austria may be dispossessed in foreign markets, and "The Engineer" confidently says, "Whatever of hundreds of millions of pounds war may cost, and whatever of human life it may consume, we are confident will be a thousandfold repaid by the renaissance of our imperial trade." It says further, "The outlook for British trade appears to be at the moment particularly bright, and the gloomy forebodings of a few weeks ago are dispersed." With such optimism and such an outlook in a country harassed by the greatest war in history, we certainly should gird on the armor of aggressiveness and throw ourselves with true American energy into the conduct of our own business and the extension of our foreign trade.

Elevator Safety in the World's Highest Building

MACHINERY accidents can never be wholly eliminated; the personal equation is involved and hidden defects may escape the most rigid inspection and tests. In the case of passenger elevators in tall buildings, the possibility of disaster from even a slight failure justifies all the precautions possible to prevent accidents. In the best practice care is exercised in the design and computations of the elevator cars and machinery, large factors of safety are used and rigid inspection is provided. Mechanical safety devices are employed, and after installation cables and machinery are regularly inspected to detect incipient defects. All these precautions were taken in connection with the elevators of the Woolworth Building, New York. Nevertheless, the designers deemed a final and automatic safety device justified by the unusual conditions imposed by the great height and the consequent serious results from a breakdown of all the precautions. Resort was had, therefore, to an old and well-known device—an air cushion at the bottom of the shaft. Its details in this installation, however, are unusual and the reader is, therefore, referred to the description on page 266.

The article gives the details, also, of a test in which a car was dropped from a height greater than the top of almost any other building, attained a velocity of nearly 180 ft. per second, and was stopped in 1½ sec., exactly as planned. Although experiments have not demonstrated the effect of such a fall on the human system, there is no good reason to believe that the velocity or pressure conditions would be fatal or even result in serious injury.

Although the principle involved in the air cushion is simple, the development of the design was difficult and involved the construction of an airtight shaft of great strength, close-fitting and quick-moving doors, suitable car construction, sensitive and reliable valves to regulate the sudden pressure, and accurate analysis and computation of the pressures developed and of the system for controlling them. The successful tests demonstrate that the factors were properly evaluated.

The effect of the installation of these cushions is noticeable in the ordinary operation of the cars, for as they near the ground floor there is a rush of air that approximates a hurricane. This objection, if it can be called such, is small indeed when compared with the safety afforded by the device.

Teaching Good Road Building

FROM the New York Commission of Highways comes a report of a school of instruction for employees of the commission which was held last spring. So far as the Engineering Record is aware, however, no publicity has heretofore been given either to the plan under which the school was organized or the work of the "classes." There was apparently a representative gathering of employees of the commission, who were addressed by experts in the construction of brick and concrete roads. After practical talks by these experts, they answered scores of questions relating to construction methods, and both in the opening talks and the discussion that followed a variety of useful information was brought out and emphasized in a way that could not fail to be of value to the men who are doing and supervising the work of the Commission of Highways.

Typical of the topics brought out were the great importance of the proper placing of the sand cushion for brick pavements; the importance of following the placing of brick by immediate rolling; the mixing and placing of cement grout; such minor kinks as the undesirability of wheelbarrows in handling brick and the saving that can be accomplished by having brick placed "best side up" for the pavers; the proper method of rolling brick on grades, and other points that those who think they are familiar with the proper methods of laying brick pavements often overlook. In the same way the best methods of preparing the foundation for concrete roads, shaping of the sub-base, causes of retarded setting-up and other important features of concrete road construction were discussed.

One sentence in the discussion of concrete road-building would have been worth printing in black type. It is this: "You cannot design a concrete pavement 4 mi. long and assume that you can use the same cross-section throughout; you will have to design it the same as foundations for a building, depending on the bearing power of the soil," etc. This is undoubtedly true, and yet it states a fact that is almost universally disregarded.

There is hardly anyone concerned in the construction of brick and concrete roads who could not profit from a reading of the commission's bulletin—which fact shows the wisdom of holding such road-building classes as the one of which this bulletin is the outcome. More schools of the same kind will amply pay for the time they occupy, and the publication of what goes on in these schools makes it possible to disseminate widely the information they bring out.

Public Improvements in War Times

WITH no desire to look for a dark lining in the war cloud, it is becoming apparent that the public pursestrings are being drawn tight at a time when it is most necessary to give employment to the greatest possible number of men on improvement works. So far as indicated by the incidents that have come to the notice of Engineering Record, this condition is due to the inability or unwillingness of bankers to buy municipal paper, and to a similar reluctance on the part of surety companies to issue bonds for large amounts. A conspicuous example of the latter condition of affairs was reported in this journal last week in connection with the postponement of a letting of the Twin Peaks Tunnel work because the surety companies would not, "under the present financial conditions," go on the heavy bond required of the contractors. "No new bonds for large amounts are being written," the article concludes. In the same week New York returned, unopened, bids on paving work because the bankers had advised the city that about all they could do would be to take care of maturing obligations; and in New Jersey, Bergen County let a 200,000-yd. contract only to find that there was no eager demand for the 4½-per cent bonds that were to pay for this work. News of similar incidents come from points as far apart as Florida and Michigan. The fundamental cause is a disposition to hold on to money, in which inclination the bankers merely reflect the feeling of investors.

But municipalities and other governmental units can find means to keep public improvements going, and evidently it is their social and economic duty to do so. If present conditions are transitory, all well and good. If money continues to be tight or scarce, it will be necessary to consider extraordinary means of financing public improvements. All any one wants is a good promise to pay. If bonds in large issues cannot be turned into cash, it will be necessary, and it is quite possible, to issue some form of script or certificate of indebtedness —in other words, "municipal paper" that local bankers and supply houses, at least, should be glad to handle at little or no discount.

If cities, counties and States throw up their hands and stop work upon encountering the first difficulties in financing improvements we shall come to a standstill for which there is no good reason—or will be none if plans are made now to find money, in spite of the difficulties that the European war temporarily imposes. These are extraordinary times and call for the adoption of extraordinary measures.

Craftsmanship Versus Money

THAT high wages alone will satisfy industrial workers and bring peace between capital and labor has been frequently enunciated and is the thesis of the letter from Mr. Fish printed elsewhere in this issue. It does not require much argument, however, to convince those who have given the matter any consideration that the theory is false. If it were true, then the hundreds of thousands of common laborers in the United States who can never hope for any increase above $1.75 or $2 per day would be most unhappy and disciples of discontent.

As a matter of fact, those who have dealt with foreign laborers realize that they are far from discontented or unhappy. Mr. Fish would protest, however, that these common laborers work out of doors and are not tied to a machine or bench, engaged day after day in brain-stunting work. Unquestionably routine machine tending leads either to stupefaction, or, in an active man, to a line of thinking which quickly becomes socialistic and revolutionary. The latter result is an easy one, because agitators are found wherever there are industries. That the only preventive to the growth of discontent with this class of workmen, however, is larger compensation is not true. Liberal wages might be an all-sufficient remedy were it possible to pay them, but economic conditions over which the manufacturer has no control frequently determine the maximum that he may pay. Betterment of processes and the increase in efficiency of the workers by proper supervision should enable the individual to do better than the average manufacturer of his district, but even then a maximum is reached beyond which higher compensation is not possible.

The true remedy lies in education, and it is in that direction that progressive manufacturers are extending their efforts for the betterment of their workers. If the man at the machine can be shown the relation of the minor operation which he performs to the finished product, if he can be given a bird's-eye view of the operations of the company as a whole, his horizon will be expanded, his latent ambitions aroused and his interest in the organization awakened or intensified. When in that condition, he is ready for advancement, and the improvement in his workmanship will quickly bring him to the notice of his foreman. This idea—a broader horizon—is basic with the continuation and the corporation schools.

One other idea might well be superadded—that of craftsmanship. Once a man acquires pride in the quality, finish or design of his product, his work rises above the commonplace, his artistic abilities, however small, are brought into play and a new ambition controls him. If the worker in a chair factory reaches the point where he shows his friends with pride a method of finish, a detail of a joint or a change in contour of a back or seat which he has originated, money alone ceases to be his goal. Ways and means of awakening this interest in work have been under serious consideration by certain groups studying industrial education. Its possibilities will appeal to those who, on a higher plane, are engaged in creative work. "Constructive thinking" has long been a slogan with those who would stimulate their subordinates to original research in any line. "Constructive handicraft" might well become a motto with those who wish to stimulate the lower classes in our industrial life. It holds forth great possibilities. It warrants the careful consideration of those who, with this journal, feel that high wages alone are not the true solution of our industrial unrest problem.

Construction of Public Buildings

EARLY in June a report was sent to Congress by the Public Buildings Commission, consisting of the secretary of the treasury, the attorney general, the postmaster general, two senators and two representatives. This commission studied the whole problem of public buildings appropriation, design, construction and management and presented both majority and minority reports. All except the postmaster general signed the main document. Nevertheless, the minority report is much the better of the two, being more comprehensive, specific and definite in its recommendations, and has received the approval of the directors of the American Institute of Architects.

As was to be expected the investigations of the commission show that an enormous amount of costly and important work is handled apparently without any rhyme or reason, so far as the amount appropriated is concerned, and that the supervising architect's office is years behind its work. There is now approximately $45,000,000 worth of work on public buildings to be placed under construction by the Treasury Department, while the supervising architect's office was able in 1913 to place under contract only about $8,000,000 worth.

The majority report recommends the creation of a Bureau of Public Buildings and the standardization of buildings by classes, and makes some minor suggestions without formulating any working system. The minority report proposes definite restriction in the area and cost limits of buildings and of the conditions under which a building is to be constructed. It recommends that a lump sum of $10,000,000 per year be appropriated for public building work, instead of the various separate items as at present. The amount to be spent on any given structure would then be determined by the commissioner of public buildings. The report advocates the authorization of sites and buildings simultaneously and the restriction of the cost of the site to 20 per cent of the total cost.

The Post-Office Department is concerned in a large majority of the buildings erected by the Government and the entire first floors of practically all public buildings are devoted to post-office purposes. It is recommended by Mr. Burleson that the required area of post-office workroom in public buildings be determined by allotting 100 sq. ft. of floor area for each employee and that the number of employees be estimated ten years in advance to allow for probable growth. Fireproof construction is not considered always indispensable, and it is shown that a post-office building should not be authorized unless the rental paid by the Government is as much as $1,000 per annum, unless the post-office receipts are $15,000 per annum or the place has a population of 5000.

The absence of a clearly defined policy has resulted in some cases in the construction of needlessly expensive buildings and in a very great discrepancy in the size and cost of buildings for substantially the same service. In other cases the limits of cost have been practically the same for widely different requirements. In some instances buildings have been authorized at a cost equal to one-half or one-fourth of the assessed value of all the buildings in their respective communities.

The expenditures of the supervising architect's office, including the care and maintenance of buildings, now amount to $21,000,000 per annum, and it is recommended that the Bureau of Public Buildings take over its administration. The architect's office would undertake the design and construction of buildings, while maintenance and repair would be in another division, both under the commissioner of public buildings. Such an arrangement is in line with up-to-date business principles and should be adopted.

Provision should also be made to supplement the architect's office by retaining under suitable conditions associated local architects and engineers. Minor buildings can be made to conform to standards in design and equipment, and their sites can be selected to avoid difficult foundations. In the case of important buildings the employment of able specialists would prove advisable and economical.

The standardization of plan and design for all but the most important buildings is highly desirable and may well include alternative designs for the same class of structure. A certain latitude may be allowed in arrangement and exterior finish of buildings in the same class, thus permitting the superficial appearance to conform to local conditions and individual tastes, without materially changing the character or cost of the structure.

The development of standards for design and construction affords an opportunity which should not be neglected. With the unlimited resources of the Federal Government, the elimination of politics, and the consideration of merit only, much can be accomplished in this direction. Most important, however, would be a reform empowering the new Bureau of Public Buildings, and not Congress, to fix the expenditures for each building. Then the merits of the case and not a Congressman's logrolling attainments would determine the size of the appropriation. This would be a bitter pill to many of the members of Congress, and for that reason the recommendations of the postmaster general will probably get no farther than a dust accumulating position in the Congressional archives.

Revamped Waterworks and New Purification Plant at Fort Smith, Arkansas

Filters of 3,000,000-Gallon Daily Capacity, Using High-Rate Wash, New Pumping Equipment, Intake and Reservoirs to Handle a Southwestern Water

PRACTICALLY the whole of the waterworks system at Fort Smith, Ark., has been reconstructed since June, 1911, when the existing plant was purchased by the city from the Municipal Water Works Company. Included in the improvements are a 5,000,000-gal. settling basin, four high-rate wash, 750,000-gal. daily filters, an 800,000-gal. clear-water reservoir, new pump house and machinery, new intake and a booster station. Features in the filter plant are the use of rate-limiting orifices in the inlet and outlet of each filter instead of rate controllers, the elimination of the holding-down screen over the graduated gravel underdrain and its replacement by a 9-in. layer of large gravel.

As now operated water pumped by the low-lift pumps is taken directly from a new intake in the Poteau River and goes to a receiving well on the east side of the settling basin, flows into the settling basin and passes over a weir on the west side into a flume connecting with a receiving chamber in the filter house. The high-pressure pumps take the filtered water from the clear-water basin and deliver it into an old settling basin 1 mi. away, transformed into a distributing reservoir.

WATER SUPPLY

Water is taken from the Poteau River 1½ mi. above its discharge into the Arkansas River. The Poteau River drains 1900 sq. mi. of catchment area, a large portion of which is mountainous, sparsely inhabited and substantially free from limestone formation. The water is soft and free from alkali, which is a characteristic quite the opposite of most of the tributaries of the Arkansas River. Under ordinary conditions of river flow the velocity is small for the last 10 to 15 mi. of the river's course; in fact, the lower 12 mi. of the river basin are a sort of a bayou, averaging about 200 ft. wide, with a measured low-water slope of 6 in. in about 10 mi. It forms a natural settling basin in which all but the very finely divided sediment is deposited. The deposits of sediment do not, however, accumulate from year to year, for the heavy periodical runoff occasions a river velocity of about 7 ft. per second, which is sufficient to thoroughly clear the prism of deposits.

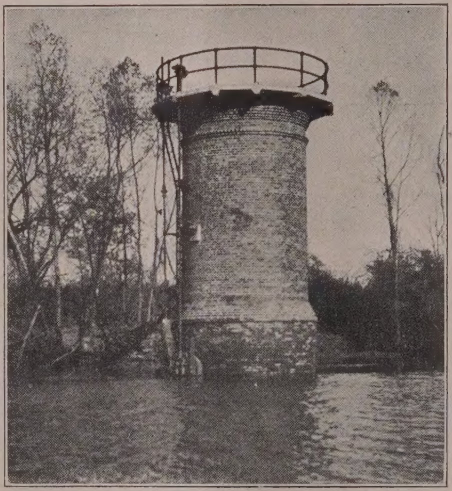
The slight fall of the lower portion of the Poteau River has its objections as well as its advantages, from the fact that any rapid rise in the Arkansas River, independent of the Poteau, creates a rapid upstream flow for several hours until the Poteau basin is completely flooded. This situation is particularly objectionable when the Arkansas high water results from floods in the South Canadian or Cimarron rivers, which carry a large amount of finely divided red sediment difficult to handle both in a settling basin and filters.

The Poteau River water, even during protracted droughts, is remarkably free of mineral matter and contains so little organic matter that there is but little vegetable growth in the water during the annual periods of stagnation. The natural alkalinity scarcely exceeds that required for use in coagulation.

A dam across the Poteau River near the site of the new water-supply works has been projected, but not yet built, for the double purpose of storage and of preventing back flow from the Arkansas River during such ordinary flood conditions as those originating in the tributaries like the Cimarron and South Canadian entering the Arkansas from the south.

NEW PUMPING STATION

Sites for the new pump house and filter plant were chosen near enough to the old pumping station to admit of the convenient use of the old boiler plant in the operation of the new pumping engines and to facilitate the work of the attendants when called upon to operate the old pumps in the old pump basement until one of the old pumps was reinstalled in the new pump house.


BRICK INTAKE TOWER

The substructure of the new pump house is of waterproof reinforced concrete, divided into an upper and a lower basement. The lower basement is 15 ft. wide and 43 ft. 3½ in. long by 29 ft. 6 in. deep in the clear, designed for three pumping units of at least 5,000,000-gal. capacity each per 24 hr. The upper basement is 36 ft. 11 in. wide by 43 ft. 3½ in. long by 13 ft. 6 in. deep in the clear. The top of the basement side walls were formed into a gallery 4 ft. 9 in. wide extending entirely around the pump house at an elevation 18 in. above the highest recorded river-flood level.

The lower basement is heavily buttressed on the outside to withstand the pressure due to 28 ft. of water anticipated during excessive floods, and the concrete floor of the upper basement is heavily reinforced with steel in a manner to transmit the weight of the pumping engines and foundation to the side walls of the building, and thence to the piers resting upon the shale substratum. The substitution of a gallery for a floor where the superstructure starts, though a departure from the ordinary methods of construction, affords a well-lighted and well-ventilated basement and was designed to do away with the dark corners and recesses where, under ordinary circumstances, it is usually found convenient to allow rubbish and dirt to collect.

SETTLING BASIN

A description and drawing of the settling basin appeared in the Engineering Record of Nov. 29, 1913, page 619, in connection with a break in the baffle wall which separated the two compartments. The slip in the earth bank of the river, referred to in the former article, at no time so threatened the security of the basin as to require the removal of the water. To obviate any further slips an underdrain was laid parallel with the west line of the reservoir, about 15 ft. from the toe of the outside slope and at a depth of about 16 ft., starting from a point about 75 ft. north of the north embankment and extending to the valve well over the 24-in. valve on the drain pipe. Also a trench was dug along the inside slope of the reservoir for about 50 ft. south and 100 ft. north of the northwest corner of the basin and refilled with puddled clay. Since then there is no evidence of further movement of the natural ground, and it is expected that the gumbo seal and underdrain will prove effective. The expense thus incurred was about $1000.

Provision is made for introducing coagulant as the water enters the basin through the receiving well and again as it enters the filter receiving chamber. Equipment is also in readiness for the use of lime and bleach as occasion may arise.

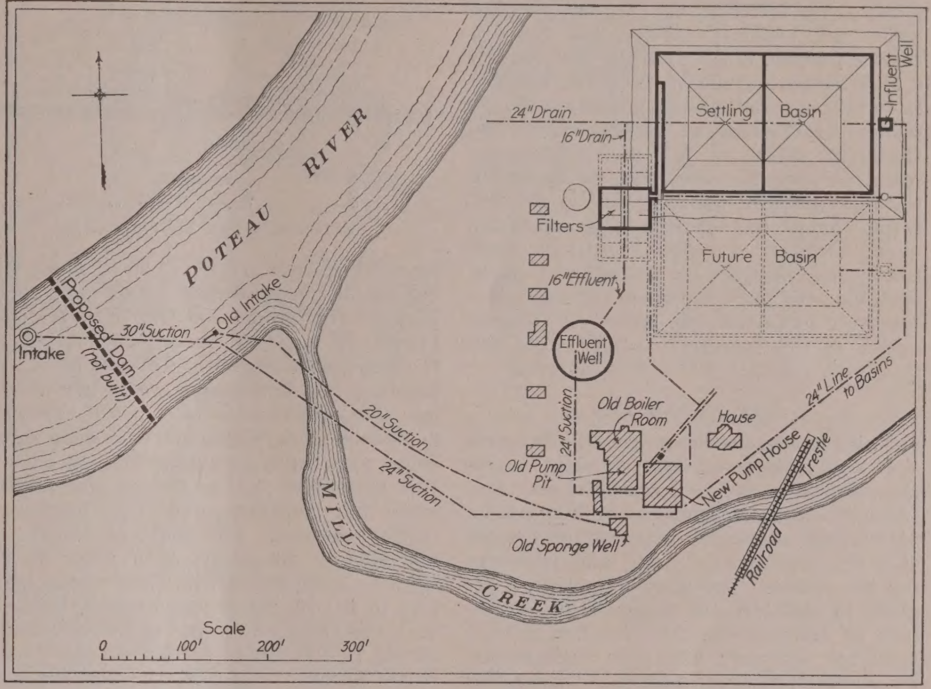
FILTER PLANT

Four filter units, with a sand surface of 14 x 20 ft., are arranged in pairs on opposite sides of a pipe gallery, with provision for additional filters to the south or north.

On the center line of the south settling basin embankment is a reinforced-concrete well or receiving chamber of the same size as one of the concrete filter units, intended for use as a coagulating well in the event that the application of additional coagulant is found necessary immediately before the water passes to the filters. Upon the opposite side of the pipe gallery from this receiving well is a basement of dimensions corresponding to those of a filter unit, containing reinforced-concrete chemical tanks.

Leaving the filter receiving well the water passes into a reinforced-concrete filter influent flume supported in part by reinforced-concrete brackets molded into the walls of the filter tanks and otherwise supported by the reinforced-concrete floor over the pipe gallery. This flume is covered with removable cast-iron plates. The pipe gallery is 11 ft. wide and contains a 16-in. effluent main, a 12-in. wash-water pipe and a 16-in. drain pipe connecting the filters with the river.

Wash water is stored in a shallow steel tank with elliptical bottom, of 40,000-gal.



GENERAL PLAN OF FORT SMITH WATERWORKS AND RIVER INTAKE

capacity, mounted on a four-post steel tower resting on concrete pedestals. A plate steel rising pipe, 4 ft. in diameter, is supported on a concrete pedestal and connects with the elliptical bottom of the tank. The 12-in. wash-water pipe connects with a 4-in. feed pipe by which the elevated tank can be filled with water from the high-pressure main. This tank was manufactured and installed by contract with the Chicago Bridge & Iron Works.

No clear-water basin is built under the filters. The collector pipes are laid in earth trenches and surrounded with reinforced concrete poured monolithic with the bottom of the filter tanks. The filter carrier system of each filter unit is of the Cincinnati type and is supplied with water through six branches from the main collector pipe.

Support for the filter sand consists of graduated gravel filled level with the top of the strainer blocks. Over this is laid about 9 in. of coarse gravel as a substitute for the ordinary brass screen. Otherwise the details of the underdrain correspond almost exactly with the plant at Kansas City, Kan., described in the Engineering Record of Jan. 27, 1912, page 88. The filter sand, about 24 in. in thickness, was obtained by screening bank sand obtained in the locality through a No. 12 screen and by washing out the undesirable fine sand after the screened sand had been deposited in the filter tank. About 82 per cent of the washed sand passes a No. 20 sieve and 3½ per cent a No. 40 sieve. The uniformity coefficient is 1.46. The three wash troughs in each filter are of cast iron.

ORIFICE CONTROLLERS

Simple filter controllers were devised consisting of a circular brass plate ⅝ in. in thickness, faced smooth and inserted in a flange joint of the branch effluent pipe of each filter. In the center of the brass plate is a beveled circular orifice of such size as to pass an amount of water equal to the rated capacity of each filter when the filter sand is clean and the filter is operating under a head corresponding to a water level in the filter about 1 ft. above the top of the sand, and a proportionately greater head as the surface of the filter sand becomes clogged. A similar plate, inserted on the branch influent pipe of each filter unit where the branch connects with the influent flume, has a circular orifice proportioned for the delivery of influent water at a rate corresponding with the rated capacity of each filter under the available head of water in the flume. By this arrangement of orifices the filters are expected to operate under a variable head with practically constant delivery, but always under a pressure head. With this type of controller no loss of head gages are needed, the level of the water in the filter tank indicating the condition of filter sand, whether clean or dirty. There is nothing to get out of order and nothing for the filter attendant to adjust. Thus far the engineers report that the filters have operated satisfactorily. The only way by which the filters can be pushed beyond their rated capacity is by pumping water into the settling basin continuously in excess of the operating capacity of the filters, thereby raising the level of the water in the settling basin and increasing the head over the influent orifice. This is a matter easily controlled at the pumps, but subjects the filters to no sudden variation of head.

The filter house simply incloses the pipe gallery, the filter valves, the receiving well and chemical room. It is a plain brick structure of paving brick laid in cement-lime mortar, supported on the walls of the filter tanks and reinforced-concrete beams. The portions of the filter tanks outside of the building remain uncovered, as no difficulty is expected from ice in the latitude of Fort Smith.

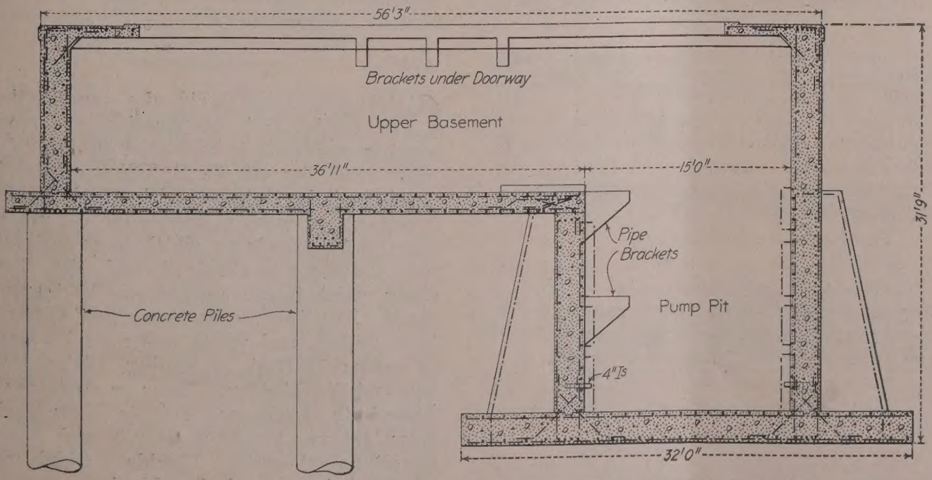
The clear-water reservoir is a large circular cistern 80 ft. in diameter, 25 ft. deep in the middle and 19 ft. deep at the curbs. The walls of the curb are of vitrified paving brick laid in cement mortar. The bottom is of concrete 4 in. in thickness, but increasing to a thickness of 12 in. under the curb walls. The flat portion of the bottom is concentric with the curb of the reservoir and 16 ft. in diameter; otherwise the bottom has a sloping surface. On the north side of the reservoir is a rectangular influent well, which receives the water from the 16-in. filter effluent pipe. The water enters this well from the filters, rises in the well and flows over a weir 10 ft. long in entering the reservoir. The elevation of the weir is 87 ft., 6 ft. below the top of the wall, and practically the same as the elevation of the collector pipes under the filters. To whatever extent the water level rises in the reservoir above the weir, back pressure is thrown upon the filters.

PUMPS AND METHOD OF OPERATION

At present two of the ultimate three Kerr steam-turbine-driven, direct-connected, Platt centrifugal pumps, each of a capacity of 5,000,000-gal. daily against a total lift, including friction, of 50 ft., have been installed. When operating triple-expansion a new high-pressure Prescott pump is able to deliver 5,000,000 gal. in 24 hr. into the storage reservoir a mile distant against a head of 216 ft., with an operating steam pressure of 135 lb. per square inch, and for standpipe or fire-service work is able, when operating compound, to deliver the same volume of water against a head of 316 ft. Upon test this engine developed a duty of 103,000,000 lb. of water raised 1 ft. high with the expenditure of 1000 lb. of steam for the engine and its auxiliaries.

Space is left for the future installation of a second engine of the same or greater capacity as the one installed, but for the present the space is occupied by one of the old pumping engines previously installed in the old pumping station.

By the old plan of operating, the en-



LONGITUDINAL SECTION THROUGH PUMP HOUSE BASEMENT, SHOWING REINFORCEMENT gines pumped directly into the hill settling basins for ordinary service, and for fire service pumped direct into the distribution system against standpipe pressure, hydraulic valves at the pumping station facilitating the transfer of service from the reservoir main to the pipe-distribution main. Under the new plan of operation the high-pressure pumping engine delivers water into the distributing reservoir under ordinary circumstances, and when fire-service pressure is desired the pump continues to deliver water through the reservoir main, but, by means of by-pass valves at the reservoir, delivers into the standpipe instead of into the reservoir.

BOOSTER SERVICE

Owing to the disadvantages of the interchangeable reservoir and standpipe service, hazards to the pipe system during and following the manipulation of hydraulic valves, lack of water in the standpipe available for high-service work, and necessity for the constant operation of pumping engines to maintain the water in the standpipe at suitable elevation for fire service, available reservoir sites for high-service reservoirs were purchased and a booster pumping station was constructed on the hill near the standpipe.

The booster pumping unit is composed of two Worthington centrifugal pumps direct-connected with an induction motor. The pumps are capable of delivering water at the rate of 1,000,000 gal. per 24 hr. into a high-service reservoir 14,000 ft. distant against a total head, including pipe friction, of 230 ft. with the pumps operated in series. Operated in parallel, water from the distributing reservoir can be forced at the rate of 2,000,000 gal. per 24 hr. into the standpipe against a total head of about 115 ft.

For the operation of the booster pumps there has been installed in the upper basement of the pumping station an Allis-Chalmers 100-kva generator, direct-connected to a condensing Kerr steam turbine. Current from a 15-kw generator direct-connected to a non-condensing Terry steam turbine is carried to a starting panel in the filter house, thence to coagulant and lime pumps installed in the filter house and to the various lighting circuits in the filter house, engineer's house and about the station grounds.

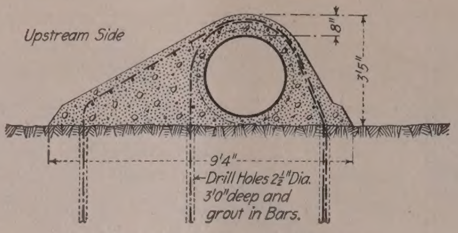
INTAKE AND SUCTION PIPE

On account of the lower elevation of the shale and the greater freedom from floating drift, the intake was located about two-thirds of the way across the river from the pumping station and about 55 ft. above the line of the proposed dam across the Poteau River. The intake consists of a circular tower, 47 ft. high above the footing in the shale, constructed of vitrified brick. In building the structure a watertight circular crib was assembled on the ground, floated to place, sunk, and the shale excavated to a depth of nearly 5 ft. to El. 47. The bottom of the excavation was leveled with the concrete and the brickwork started thereon. The shaft is 10 ft. in diameter in the clear, with walls 37 in. thick to shale line, 25 in. thick above shale line to El. 72, where the brickwork insets to a thickness of 17 in. and subsequently offsets at the top to form a cornice 25 in. in thickness. At El. 71 the brickwork is corbeled out 3 in. on the inside of the shaft to form bearings for the framework supporting horizontal screens. The top is covered with an octagonal reinforced-concrete slab, 6 in. thick, circumscribing a circle 18 ft. 8 in. in diameter. There is a rectangular opening in the concrete slab 9 x 3 ft., concentric with the shaft, affording an approach to the interior of the shaft and admitting of manipulation of the screens. Otherwise the concrete cover affords room for the attendants to operate the sluice gates and clean the screens.

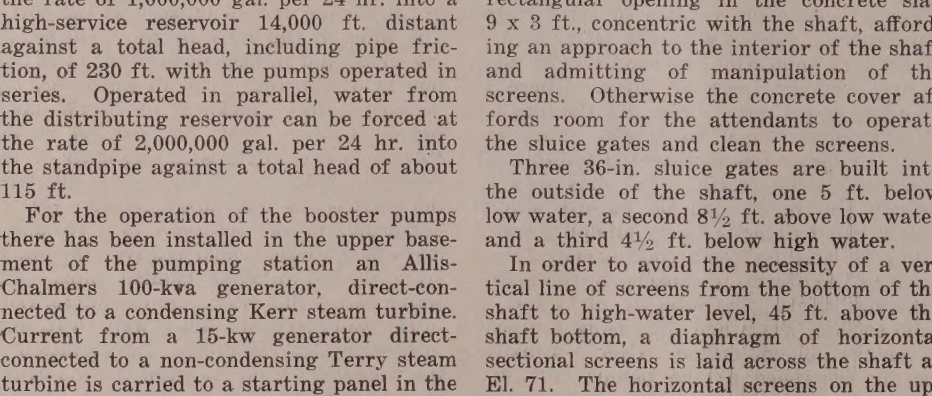
Three 36-in. sluice gates are built into the outside of the shaft, one 5 ft. below low water, a second 8½ ft. above low water and a third 4½ ft. below high water.

In order to avoid the necessity of a vertical line of screens from the bottom of the shaft to high-water level, 45 ft. above the shaft bottom, a diaphragm of horizontal sectional screens is laid across the shaft at El. 71. The horizontal screens on the upstream side of the shaft are anchored to avoid possible displacement of screens by floating matter which may find access to the intake through the two lower gates during periods of rising water.

The end of the 30-in. suction in the intake crib is a 90-deg. flanged bend pointing downward, the bottom of which is at El. 50. Between the intake and shore the suction line is laid on the shale diagonally with the current of the river, with a slight rising inclination toward the pumps. It is secured with steel rods anchored into the shale and is to be protected further by a covering of reinforced concrete.



ANCHORAGE FOR SECTION LINE



CROSS SECTION OF FILTER AND PIPE GALLERY

COSTS

Expenditures for the various structures are: Pumping-station basement, $12,863.18; station superstructure, $11,794.73; settling basin, $29,377.68; concrete filters, $19,194.16; filter superstructure, $2,646.05; intake, $7,139.68; clear well, $6,781.41; wash-water tank and foundation, $3,769.65; high-pressure pumps and foundation, $14,060.38; low-service pumps, $8,155.56; pipe about station grounds, $16,367.50 (of this the suction and discharge lines of the pumps cost $13,439.09, the pressure line to filters and basins, $728.74, and the 30-in. suction in the river, $2,199.67); steam piping and hot well, $1,490.04; engineer's dwelling, $4,385.71; coal bin, $1,866.90; booster station, $4343; electrical equipment, $8931, and tools, supplies and miscellaneous, $6596.

Improvements and extensions of the waterworks at Fort Smith were designed by Wynkoop Kiersted, consulting engineer, of Kansas City, and constructed under his direction and supervision for the Board of Improvement, Waterworks District No. 1. Contracts were let only for material needed, the construction being carried out by force account under W. A. Bott, resident engineer, and R. R. Applegate, foreman of construction. Work was begun May, 1912, and the new plant went into operation August, 1913, under the direction of Wallace H. Bruce, water commissioner.

Reinforced-Concrete Roof Tiles

REINFORCED-CONCRETE roof tiles have been placed on a number of buildings constructed in connection with the Catskill Aqueduct, according to the 1913 report of the Board of Water Supply of New York City. The tiles were made of 1:2 mortar reinforced with 1½ x 3-in. wire mesh. All tiles except the hip tiles were made with the weather surface up, shaped and surfaced with a special steel screen. The hip tiles were cast in sand molds. Under test the flat tiles showed an ultimate strength of 30 lb. per inch of width when centrally loaded on a 35-in. span, and were impervious under a 3-in. head of water when twenty-eight days old. In place, they also stood well under rains and snows, showing no leakage at any time. From the satisfactory results of this experiment it was determined to use concrete tiles to roof all aqueduct superstructures.

CONVICT LABOR in the construction of roads and preparation of road-making materials is to be the subject of a joint study by the U. S. Office of Public Roads and the Public Health Service. The investigators wish to determine the conditions and methods by which most satisfactory results are obtained and the lines along which improvements may be inaugurated. The first studies are about to begin in Colorado, and visits will next be made to camps in Utah, Wyoming, Idaho, Oregon and Washington. Later on studies will extend to Michigan, Illinois, New York, New Jersey, Virginia, North and South Carolina, Georgia, Florida, Oklahoma, Texas, Arizona, and New Mexico.

Economical Depth of Covered Reservoirs

Derivation of Formulae and Curves for Obtaining the Most Suitable General Dimensions for Groined-Arch Construction

By FRANK H. CARTER
Assoc. M. Am. Soc. C. E., Designing Engineer, Cambridge, Mass.

COVERED-RESERVOIR construction methods have decreased the cost of reservoirs from time to time until to-day the economical depth of reservoirs to hold a given quantity of water is somewhat different from that of fifteen years ago. The use of groined arches of plain concrete for reservoir roofs has been followed by the futher thinning of the average thickness of the roof by depressing the top of the roof over piers. A radical saving has been effected in the cost of the side walls, the later designs having reverted to an extremely light section, which is only in a limited sense a gravity wall. It has also been found cheaper to cut off the lower bottom corner of the reservoir section to save the height of the side walls.

It was during the preliminary design of a 20,000,000-gal. reservoir that the following facts were deduced. First, an investigation of the economic depth was made. The cost of a covered reservoir is cost of excavation, plus cost of roof and floor, plus cost of piers, plus cost of side walls.

In the case of the cost of walls and excavation the cost varies as the 3/2 power of the height and length respectively, instead of as the square, as previous writers have demonstrated. Assuming costs of concrete per cubic yard as follows—piers, \$9; roof, \$8; walls, \$7, and floor, \$6, and using John H. Gregory's formulæ given out in 1901, for the average thickness of roof and floor, adopting in these formulæ (see Fig. 1) a uniform span of 14 ft. in the clear, with piers 20 in. square, a rise of 3 ft. and a crown thickness of 6 in., with the allowable depression over each pier in the roof, the cost of roof and floor per square foot is found to be as follows:

Roof (7.65-in. average thickness)	\$0.189
Floor (7.15-in. average thickness)	.133
Floor (sub-floor, 4-in. thickness)	.074
Total	\$0.396

For the piers the average thickness distributed over the whole reservoir per 1-ft. height is (20 × 20 × 12) ÷ (15.67 × 15.67 × 144) = 0.136 in. The pier costs per square foot are as follows: For 10-ft. depth of reservoir, \$0.0378; for 20-ft. depth, \$0.0755; for 30-ft. depth, \$0.1133, and for 40-ft. depth, \$0.1511.

The cost of the walls 30 in. thick sloping 1 in 24 on the back was found to be $\$0.12h^{1.5}$. Hence the costs per linear foot are as follows: For 10-ft. depth, \$3.78; for 20-ft. depth, \$10.70; for 30-ft. depth, \$19.60, and for 40-ft. depth, \$30.30.

The costs of excavation and backfill per square foot at 60 cents per cubic yard for a reservoir of 20,000,000-gal. capacity are, very roughly, \$0.094 for 10-ft. depth, \$0.181 for 20-ft. depth, \$0.299 for 30-ft. depth and \$0.443 for 40-ft. depth, or the cost of the excavation and backfill for the reservoir is, very closely $\$0.17hx^{1.5}$.

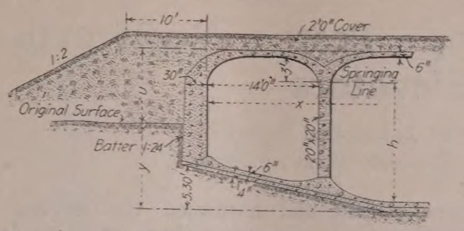


FIG. 1—ASSUMED DIMENSIONS OF RESERVOIR

Now let C equal total cost of reservoir; h, depth of water from invert to springing line of roof; c, coefficient of $h^{1.5}$ to represent the cost of the side walls; x, inside dimension of square reservoir; c_1, coefficient to apply to height multiplied by $x^{1.5}$ to obtain cost of excavation; c_2, coefficient to apply to x^2 to obtain cost of roof and floor, and c_3 coefficient to apply to h to obtain cost of piers per square foot. Then

$$C = 4ch^{1.5}x + c_1x^{1.5}h + c_2x^2 + c_3hx^2$$
$$= 0.48^{1.5}x + 0.17hx^{1.5} + 0.396x^2 + 0.00378hx^2$$

But

$$Q = hx^2$$

or

$$x = \sqrt{Q/h}$$

Therefore

$$C = 0.48h^{1.5}Q^{0.5}/h^{0.5} + 0.17h^{0.25}(Q^{0.5}/h^{0.5})^{1.5} + 0.396Q/h + 0.00378hQ/h$$
$$= 0.48hQ^{0.5} + 0.17h^{0.25}Q^{0.75} + 0.396Q/h + 0.00378Q$$

For a minimum value of C

$$\frac{dC}{dh} = 0.48Q^{0.5} + (0.17Q^{0.75}/h^{0.75})/4 - 0.396Q/h^2 = 0$$

or

$$0.48Q^{0.5}h^2 + 0.0425Q^{0.75}h^{1.25} = 0.396Q \qquad (1)$$

This equation may be solved by trial, and is plotted to a logarithmic scale in Fig. 2.

The work may be simplified by using the approximation $0.01hx^2$ as the cost of excavation instead of $0.17hx^{1.5}$. Then

$$C = 4chx^{1.5} + c_1hx^2 + c_2x^2 + c_3hx^2$$
$$= 0.48h^{1.5}x + 0.01hx^2 + 0.396x^2 + 0.00378hx^2$$

But

$$Q = hx^2$$

or

$$x = \sqrt{Q/h}$$

Therefore

$$C = 0.48h^{1.5}Q^{0.5}/h^{0.5} + 0.01hQ/h + 0.396Q/h + 0.00378hQ/h$$
$$= 0.48hQ^{0.5} + 0.01Q + 0.396Q/h + 0.00378Q$$
$$= 0.48hQ^{0.5} + 0.01378Q + 0.396Q/h$$

For a minimum value of C

$$\frac{dC}{dh} = 0.48Q^{0.5} - 0.396Q/h^2 = 0$$

and

$$h = \sqrt{0.396Q/0.48Q^{0.5}} = 0.91Q^{0.25} \qquad (2)$$

Table 1 gives the economical dimensions for reservoirs of various capacities as derived from formula (2) and also the economical depth as derived from the more accurate formula (1).

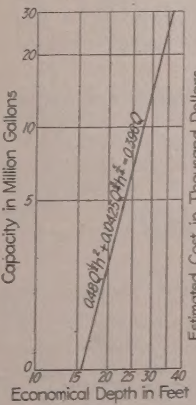


FIG. 2—CURVE FOR ECONOMICAL DEPTH

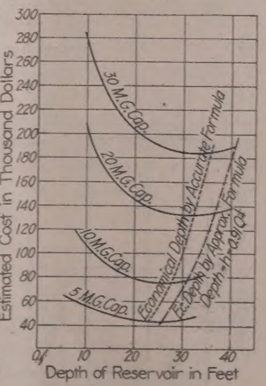


FIG. 3—CAPACITY, DEPTH AND COST

TABLE 1—ECONOMICAL DIMENSIONS OF RESERVOIR

Q Million gal.	Q Thousand cu. ft.	h (formula 2) ft.	Side of square reservoir, *ft.	h (formula 1) ft.
1	133	17.3	87.7	15.5
2	267	20.7	113.5	18.5
4	533	24.6	147.2	21.8
6	800	27.2	171.5	24.2
8	1067	29.3	191.1	26.0
10	1333	30.9	207.0	27.7
12	1600	32.3	222.5	28.7
14	1870	33.6	235.5	30.0
20	2670	36.7	269.5	32.6
30	4000	40.7	314.0	36.3

*Using h from formula 2.

It is seen that the more accurate formula gives a depth about 90 per cent of that obtained from the other (see Fig. 3).

To make the cut balance the fill, allowing 10 per cent for shrinkage of the embankment, the following equation must hold from Fig. 1:

$$\frac{100}{110}\left[\frac{(x+6)^2(h+4-u)}{27} - 9(x-5)\right]$$
$$= \frac{u+2}{81}\left[(x+20)^2 + (x+28+4u)^2 + \sqrt{(x+20)^2(x+28+4u)^2} - \frac{(x+4)^2u}{27}\right]$$

where u = distance from top of concrete roof to the ground and $9(x-5)$ represents the saving effected by cutting the bottom corner. This equation was solved for a number of cases as shown in Table 2.

TABLE 2—DEPTH OF EXCAVATION CUT IN FEET TO BALANCE FILL

Capacity, million gal.	Depth of water 10 ft.	20 ft.	30 ft.	40 ft.
5	6.1	11.5	18.5	....
10	5.3	10.3	16.4	....
20	4.6	8.5	13.8	19.9
30	3.9	7.7	12.5	18.5

Having obtained the economic depth of reservoir the cost is easily obtained by multiplying the unit values given by the quantities, to which should be added 15 per cent for engineering and contingencies and about 20 per cent more for gatehouse and connections.

TABLE 3—APPROXIMATE UNIT COSTS

Capacity, million gal.	Cost per million gal.*
30	\$6,300
20	6,850
10	7,700
5	8,050

*Figures include addition of 15 per cent for engineering and contingencies and 20 per cent for gatehouse and connections.

As a check on estimates or for preliminary figures the cost per 1,000,000 gal., using the unit figures already given, is as shown in Table 3.

DRAINING MOSQUITO BREEDING GROUNDS has proved so difficult at New York, N. J., that dikes 2 ft. high and 4 ft. wide are to be built in front of 200 acres of meadow, the only outlet for which, Peddie Ditch, is inadequate to carry away the water. It is also planned to use tide-gates at advantageous points, and it may sometimes be necessary, states John W. Dobbins, chief inspector of the Essex County Mosquito Extermination Commission, to pump out the water after excessive rains.

Six Hundred-Foot Drop Tests Woolworth Building Elevators

Car Falls Forty-five Stories and Is Stopped Safely by an Air Cushion in Steel and Concrete Pressure Shaft

RECENT tests of the automatic safety cushions in the bottoms of the shafts of the very high passenger elevators in the Woolworth Building, New York City, have demonstrated a high degree of efficiency in smoothly, quickly and safely stopping the cars when falling freely from their maximum height of about 600 ft. The application of the air-cushion system involved the construction of heavy airtight walls inclosing the bottom of the elevator shafts for several stories and capable of resisting a high, sudden internal pressure. There are also provided strong airtight entrance doors in different stories and special outlet valves to release the air and maintain the desired pressure under the piston action of the air. Inlet valves eliminate suction from ascending cars.

ELEVATOR EQUIPMENT

The Woolworth Building has one of the largest and highest sets of passenger elevators ever installed. There are twenty-six electrically operated cars designed for a combined capacity of about 6000 passengers per hour in each direction carried at a speed of 600 ft. per minute for the low rises and 700 ft. per minute for the high rises. They are of the Otis standard gearless type, such as are used in the Metropolitan Life Insurance tower, Singer tower and other high buildings, and have cars of from 30 to 50 sq. ft. floor area which are provided with the usual safety appliances for stopping them in case of accident or excessive speed. Two cars travel 679 ft. from the first to the fifty-first story, two travel about 606 ft. from the first to the forty-sixth story, two travel 530½ ft. from the basement to the fortieth story, fourteen travel 358½ ft. from basement to the twenty-seventh story, two travel to the twenty-eighth story and four travel to the twelfth story.

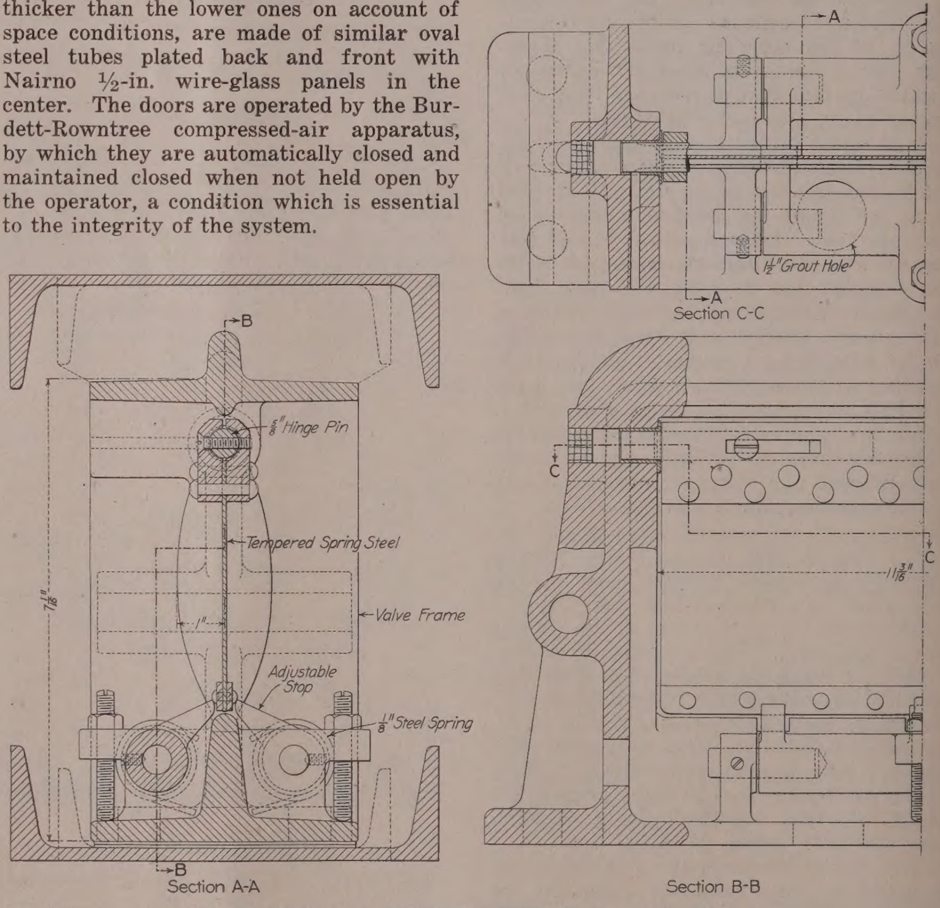
AIR CUSHIONS

To provide a safeguard against injury by too rapid descent each elevator has the lower portion of its shaft inclosed in airtight steel and concrete walls, adapted to retain the air under the plunger action of the descending car and form an elastic cushion, bringing it gradually to rest. The cushion walls extend up to the fourth, fifth, seventh, eighth and eleventh stories, according to the height of the elevator shaft, and have a maximum effective height of 135 ft. 3½ in. The walls are of concrete reinforced with horizontal web I-beams, except in cases where the counterweight walls are too close to the car shaft to admit the concrete construction. Steel buckle plates are used to cover the counterweight shaft.

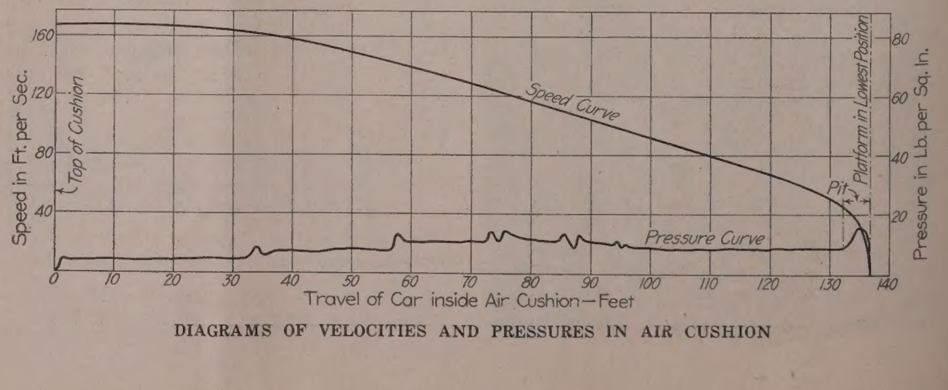
In all cases the faces of the walls are parallel, except at the bottom, where for a distance of about one story they are narrowed to fit the car quite closely. The webs of the I-beams on all four sides of the shaft are in the same horizontal plane and are cut to clear; they are spliced together at the corners by top and bottom web cover plates. They are connected to the structural columns by hitch angles and have grouting holes through the web. The lower 18 ft. of the walls are "cladded" with Portland cement and hardwood, the elevator platform with trimming pieces being used as a template allowing from ¼ in. to ½ in. clearance.

The calculated average pressure required was less than 15 lb., but it was assumed that in service an instantaneous pressure slightly exceeding 20 lb. per square inch might be developed in the air cushion, and the walls were proportioned to withstand a pressure of 15 lb. with a maximum fiber stress of 20,000 lb. per square inch, the possible theoretical excess of the pressure not being computed to exceed the elastic limit. Under test the actual maximum pressure at the bottom of the cushion was about 18 lb. To resist these pressures, the lower doors are made of flattened drawn-steel tubes having an elastic limit of 44,000 lb., with tongues at the bottom, which are held in steel sills firmly built into the floor concrete. The upper doors, which could be thicker than the lower ones on account of space conditions, are made of similar oval steel tubes plated back and front with Nairno ½-in. wire-glass panels in the center. The doors are operated by the Burdett-Rowntree compressed-air apparatus, by which they are automatically closed and maintained closed when not held open by the operator, a condition which is essential to the integrity of the system.

In the lowest 15 ft. of the air cushion the clearance between the car and the wall is one-thirty-fifth the area of the car; above that point it is one-fifteenth the area of the car. The natural efflux of air between the car and the sides of the shaft is therefore constant for nearly the full height of the cushion, and without regulation would result in an intensification of pressure at the bottom of the shaft and in violent changes of velocity. To regulate these conditions the air in the cushion is controlled by special outlet valves set in the walls at different heights and adjusted to open instantaneously under a pressure of 12 lb. per square inch, or slightly less than the calculated pressure to allow for their inertia. They are disposed vertically in the shafts, so that as the falling car passes it cuts off their areas consecutively. Thus the car itself reduces the area of efflux so as to render retardation theoretically nearly uniform. There are in all 126 outlet valves, each having an area of 0.4 sq. ft. As no standard valves could be obtained which were sufficiently free from inertia to be satisfactory for this purpose, special valves were designed by Thomas E. Brown to secure positive, accurate, and rapid action.



OUTLET VALVE FOR RELIEVING PRESSURE IN AIR CUSHION



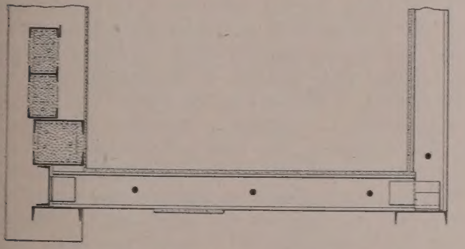
DIAGRAMS OF VELOCITIES AND PRESSURES IN AIR CUSHION

They consist of sheets of 1/32-in. tempered spring steel about 5 in. wide. The upper edge is securely clamped to a hinged bar and the reinforced lower edge is normally confined between adjustable stops on both sides. Under the required pressure the deflection of the thin plate displaces the lower edge sufficiently to clear the stops, and the valve swings open.

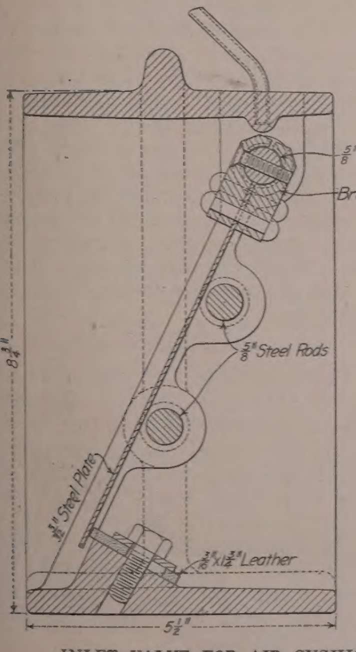
INLET VALVES

In order to prevent retardation of the cars in normal service when lifted out of the cushions seventy-two inlet valves about 12 in. long and 6 in. wide are set in the lower part of the walls. They are simple check valves made of inclined steel plates hinged on the upper edge and bearing on the lower edge against leather stops. They are opened by the exterior atmospheric pressure whenever there is any reduction in the air-cushion pressure, and when the latter is above normal they are held securely in place by coming into contact with horizontal supporting bars that prevent their deflection, but present little resistance to the inflow of air.

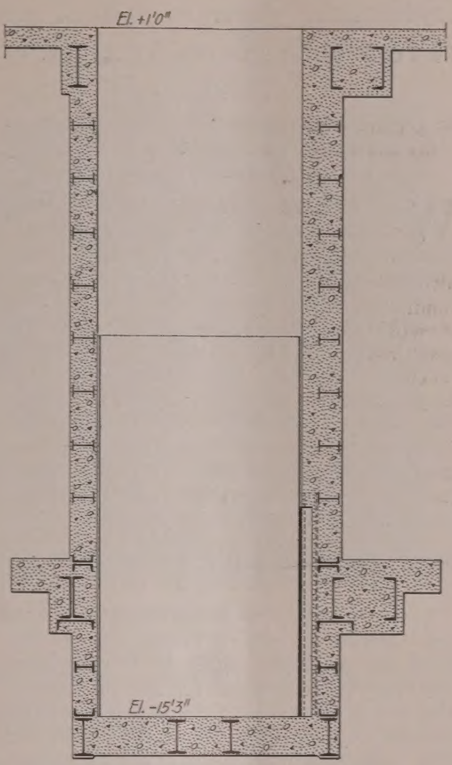
On the night of Oct. 16, 1913, one of the forty-six story cars, loaded to a total weight of 7500 lb., corresponding to a carful of passengers, was dropped freely from the forty-fifth floor and stopped safely by the action of the air cushion. It fell 470 ft. to the top of the air cushion in 5½ sec. and came to rest safely at the bottom of the air cushion in about 1½ sec. more. The cushion worked satisfactorily and the car doors and walls showed no indication of injury. The velocity in the cushion part of the shaft was reduced regularly and uniformly, and the pressure developed in the body of the cushion did not exceed 15 lb. per square inch, except at the last moment at the bottom of the pit, when it was increased to a maximum of 18 lb.



SHAFT FRAMING FOR AIR CUSHION


$\frac{5}{8}$" Hinge Pin
Brass Bushing
$\frac{5}{8}$" Steel Rods
$\frac{3}{32}$" Steel Plate
$\frac{3}{16}$"x$1\frac{3}{4}$" Leather
$8\frac{3}{4}$"
$5\frac{1}{2}$"

INLET VALVE FOR AIR CUSHION



SHAFT TO RESIST CUSHION PRESSURE

TESTING APPARATUS

The testing apparatus consisted of six specially designed steam-engine indicators with large drums equipped with electric magnets to hold the pencil points off the drums until the magnet current was broken. All the drums were rotated at constant speed by electric motors. Four indicators were connected with the shaft by pipes—one at the bottom and the three others at nearly equal intervals up to the fifth floor.

Two indicators were placed in the car. One was connected to the interior pressure by a pipe through the bottom of the car and the other to a water column carried in the car, consisting of a brass tube about 7 ft. high, to register the intensity of retardation. The motor revolving the drums of the two indicators in the car was equipped with a flywheel heavy enough to maintain constant speed during the short time of the fall, as current was cut off from this motor by the pulling out of a plug the instant the car left its starting point at the forty-fifth story. The magnet current of the fixed indicators was carried by a wire stretched across the top of the air-cushion shaft, which was broken by the car at the instant it entered the cushion.

The cushions and auxiliaries were designed by Thomas E. Brown, consulting engineer of the Otis Elevator Company, who planned and directed the test. Cass Gilbert was the architect of the building, and the Thompson-Starrett Company was the general contractor and installed the air cushions and valves.

KENSICO DAM of the Catskill Aqueduct, New York, as originally designed had a downstream profile consisting of two circular arcs and two tangents, which, on the suggestion of the consulting architects, has been changed to a hyperbola. The new profile at no point departs as much as 12 in. from the former profile.

Americans Need to Be Advised as to South America's Financial Condition

"Utmost Caution" and Closest Attention to Trade Customs Urged by G. H. Charls

A RECENT South American trip, made in the interest of his company, has qualified G. H. Charls, assistant secretary and sales manager for the American Rolling Mill Company, of Middletown, Ohio, to discuss in detail the present opportunities in Latin America for American manufacturers. When asked for his views by the Engineering Record, he began by emphasizing the need for the "utmost caution" on account of the conditions that have prevailed in all South American countries for the last year. He pointed out that even the most representative South American merchants are proceeding cautiously because of the financial readjustment occurring there.

South America has relied upon foreign capital to finance practically all of its big undertakings. With the beginning of the Balkan War a money tightness became prevalent. Land speculation drove the price of many properties to twice their real value. Money borrowed from Europe paid for these lands. To-day many owners of fine camps and plantations find themselves in the position of being able to earn just sufficient profit to pay the interest on their loans. Misfortunes in crops have embarrassed these owners seriously.

These conditions were in existence before the great crisis in Europe. The war has made it impossible for these growing countries to float their loans abroad and unless the bankers and capitalists of the United States go to their relief dull times will continue to prevail.

RECIPROCAL RELATIONS OF SOUTH AMERICA AND EUROPE

Too many of us are aroused to action by the fact that England, Germany and France, who formerly controlled the lion's share of South American business, are now at war. We must keep in mind that these same countries consumed a proportional amount of the exported products of all South American nations. These conditions will not tend to lighten the financial situation which was so serious before the European war began.

The merchants of Brazil, Argentina and Chile are not accepting orders without full information on the financial standing of their customers, and it will be well for United States manufacturers to follow their example.

In Mr. Charls's opinion two very important steps must be taken by North Americans to secure a permanent, profitable business relation with the nations south of us. The first is proper shipping facilities. Some important and successful efforts to accomplish this task are now in progress, but all need the hearty support of every manufacturer interested in this field. The second is an awakening of United States bankers and capitalists to the splendid opportunities for investment offered them in that field.

A year ago in Europe Mr. Charls learned that one of the large enterprising American railway firms operating in Argentina and Brazil was forced to appeal to English and French capitalists. The European capitalists, in cases of this kind, exact that

European products exclusively be purchased.

Many of the largest systems of railways, rubber plantations, nitrate fields, public utilities, mines, etc., are financed by Europeans on this basis. Therefore, notwithstanding the recognized superiority of United States products, we lose the order. Mr. Charls called upon the chairman of one of the largest railway systems in Brazil whose headquarters were in London. He said: "If we intended purchasing $100,000 worth of material we would dislike very much for one dollar's worth of this business to be purchased in the United States if it could be produced in Europe."

Mr. Charls said that too much emphasis cannot be placed on the danger of this impediment to the success of the manufacturers of the United States in endeavoring to secure a successful foothold, and urged that it be given due consideration by our financial institutions.

RESPONSIBILITY OF AMERICAN MANUFACTURER

The present deplorable conditions in Europe impose a great responsibility on American manufacturers, he believes. There are great fields of opportunity open in South America, and the people are in need of our products. Their former source of supply of capital and products is cut off, for the time being at least.

We may either improve or endanger our future relations with those countries by our actions and methods of doing business at this time. The Europeans have made a careful study of the needs, the temperament and business customs of these people. Our methods in the United States are very different, and business policies that apply here will not be looked upon with favor there.

South America is full of intelligent, shrewd men, honest and reliable. They are proud of the progress they have made, and if we wish to gain their confidence we must send them just what they order to the last detail; we must do business with them as they are accustomed to doing it and devote all our efforts to please them and win their respect.

Mr. Charls was positive this can be accomplished in one way only—by sending experienced, tactful representatives, speaking fluently the language of the country they visit, to study conditions, make acquaintances and, most important, to ascertain the exact requirements of the trade, and then by filling those requirements without one hint of substitution.

By this procedure due caution will be observed and financial risks minimized on immediate business. By no other means can an enduring commercial supremacy be gained in this land of opportunity.

PAVING SPECIFICATIONS for tar-macadam in Glasgow, Scotland, are practically left to the contractor. George W. Tillson, consulting engineer to the president of the Borough of Brooklyn, New York City, stated in his recent report of an examination of European paving practice that 9,000 sq. yds. of this type of road were placed on the streets of the great shipbuilding city during the year ended May 31, 1912. The city has drafted a contract reading as follows: "The contractor shall describe fully the nature of the tar-macadam tendered for, the mode of laying and the time which will be occupied in executing the work."

Optimistic View of Effect of Present Crisis on American Trade

W. J. Clark Expects Some Small Immediate Benefits and Larger Ultimate Gains, Particularly from South American Business

W. J. CLARK, manager of the traction department of the General Electric Company, takes an optimistic view of the ultimate effect of the war upon industrial conditions in this country, but he feels that it will take time to adapt our financial machinery to the new conditions. In an interview with a representative of the Engineering Record he pointed out that European financiers have made a diligent study of foreign business for such a long time that Americans cannot expect to learn the art of dealing with South American countries especially in a few months.

BELGIUM'S POSITION IN SOUTH AMERICAN FINANCING

In his opinion a vital feature in the European industrial achievements abroad has been the attention given to the financial standing of individual foreign customers. The status of each as a creditor is carefully studied and suitable terms are made for him. Credits up to two years are sometimes allowed, with a reasonable interest rate which can be discounted at home, making a profitable transaction for seller as well as purchaser.

Belgium, which has been so far the center of conflict in the present war, has played an important part in the financing of foreign undertakings. It has been to a considerable extent a clearing house for them, due to favorable laws, to the supposedly neutral character of the country and to the excellent Belgium consular service. Corporations in other countries invested through Belgian corporations somewhat as though they were holding companies. The capital thus placed outside of Belgium in public utilities of various kinds is at least $1,000,000,000. There are also vast sums invested directly by French, German and other financiers.

In South America the public utilities, with the exception of the Pearson, Grace and minor interests, are financed in Europe principally, directly or indirectly, from Germany. To offset the conditions outlined, Mr. Clark believes that, aside from the temporary and possibly permanent conditions produced by the present war, the principal advantages possessed by American manufacturers lie in the quality of their products and the ability of their selling forces. That our manufacturers are beginning to appreciate their opportunity is shown by the activity of the United States Steel Corporation and a few other enterprising organizations.

The General Electric Company does much of its South American business through its London office, opened fourteen years ago, largely to handle foreign business. A very large business is done there because London is the natural center for South American trading. The company also controls the South American General Electric Company, with headquarters at Buenos Aires, and it has regular office headquarters at Rio de Janeiro. In addition, a large business is handled by W. R. Grace & Company in the west and southwest, and by Amsinck & Company in the north.

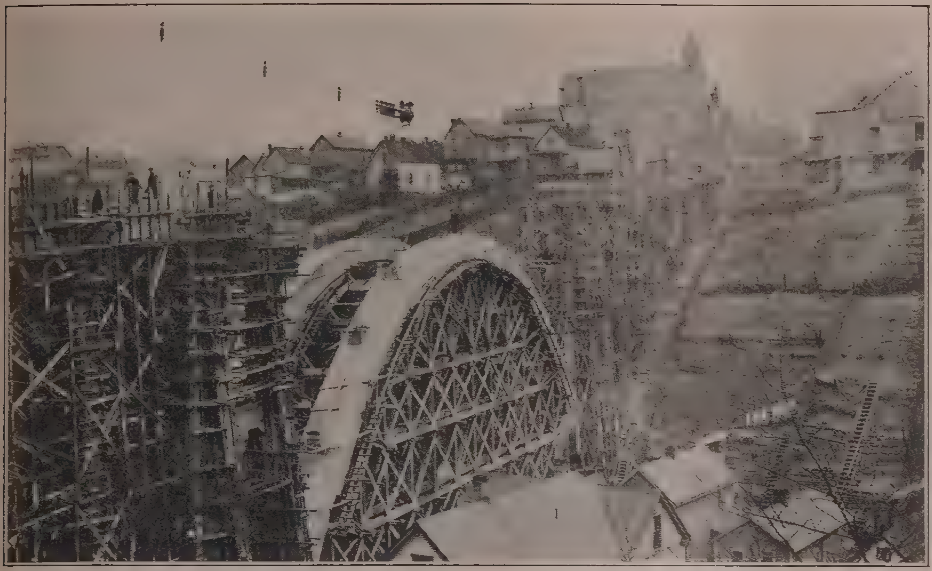
In discussing the probable effects of the war upon financial and industrial conditions, Mr. Clark stated that he expects some small immediate benefits and larger ultimate ones. At first there should be an increase in the demand for small supplies for which the purchaser can pay directly. The present plants must be kept up, as supplies will be required at once. Ultimately foreign projects will have to be partly, and possibly largely, financed from America. Europe up to this time has largely financed all foreign undertakings, but America must shoulder part of the burden, because European money will be needed at home. As foreign ownership influences trade to a large extent, it follows that, as fast as American money is invested abroad, American trade will follow it. South America has little money of its own, hence must depend upon the outside world for capital. The conditions for investment, moreover, are favorable, and they are constantly becoming less so in this country, at least so far as public utilities are concerned.

In Mr. Clark's opinion the close of the war will be followed by an influx of very desirable immigrants, who will flee from the burdens which inevitably follow a great war. South America will share in this benefit, as it did fifty years ago, when some of the present prosperous Irish and other families settled there, particularly in the River Platte country. The reaction of the war will probably also be seen in the increased costs of manufacturing in Europe, both in labor and supplies, through high taxes and shortages due to destruction and non-production. These will act as a protection to American industries, enabling them to offset the results of tariff reductions.

Relation of Porosity to Disintegration in Concrete

TESTS on porous concrete to forecast the effect of waters of the Catskill Aqueduct city shafts on the strength of grout were conducted during 1913 in the laboratory of the Board of Water Supply, New York City, by allowing city water to percolate through it for a year. The result, as presented in the board's annual report for 1913, showed that the strength was reduced to a small fraction of the normal strength. Other tests showed that if a small quantity of magnesium sulphate or sodium sulphate was added to the water, the decomposing action on the concrete was greatly accelerated. If acid was present the destruction was hastened, the rapidity of disintegration depending upon the construction of the acid solution. Impermeability is the quality of concrete which more than any other is conducive to durability under all conditions, and indications are that an ample proportion of cement is the most expedient means of attaining impermeability, according to the report. The aggregates should be well balanced and the mixing of the concrete thoroughly done.

LIME manufactured in the United States in 1913 amounted to 3,595,390 tons, valued at $14,648,362, according to R. W. Stone, of the United States Geological Survey. This was an increase over 1912 of 65,928 tons in quantity and of $678,248 in value. The average price per ton in 1913 was $4.07, as compared with $3.96 in 1912 and $4.03 in 1911. While Pennsylvania is the largest producer, its output is only 2.36 per cent of the total, indicating the wide distribution of the industry.



TIMBER FALSEWORK FOR 150-FOOT MAIN CONCRETE ARCH

Design of Monessen Concrete Viaduct with 150-Foot Arch Span

Calculations of Ribs and Details of Falsework for $52,500 Structure, with Notes as to Assumed Loadings and Unit Stresses

By THOMAS FLEMING, Jr.
Of Chester & Fleming, Engineers, Pittsburgh

SEPARATED by a deep ravine, two sections of the city of Monessen, Pa., have been connected by a reinforced-concrete viaduct 510 ft. long, having a main arch span of 150 ft. With the new bridge in service a long detour between important parts of the residential district is avoided. The bridge is 32 ft. wide and carries a 20-ft. driveway and two 6-ft. sidewalks. The general features of the design are shown in the accompanying drawings and photographs. A difference in elevation of 22 ft. exists between the connecting streets on each side of the valley, necessitating a 5 per cent grade on the bridge. The usual line loads were assumed and provision was made for interurban street cars.

The cost, $52,500, is considerably below the cost of any similar structures built in the vicinity under like conditions, but the city officials were limited to this amount, and it was therefore necessary to make the lines and details as simple as possible and to avoid ornamental features. After several studies it was decided to use a plain design and to get a good architectural effect mainly by shading obtained from offsetting portions of the structure. The cantilevering of the sidewalks and overhang of the floor slabs gave this effect for the upper part of the bridge. The columns over the abutments were built out beyond the center lines and arranged to give a tower effect. This was carried out to the floor system, where an offset over these towers was also made.

DESIGN

Before beginning the design a complete survey was made of the site, and test holes were dug along the center line. A superficial inspection of the site showed a shale formation outcropping on the slopes, with horizontal stratification, and having indications of solid rock below the surface. The test holes showed that along the slopes solid rock could be obtained at a depth of 3 or 4 ft., but that in the valley it would be necessary to go to a much greater depth. As the valley was occupied by a street and was comparatively narrow, an arch of reasonable span would easily clear it, so that the absence of rock foundation in the valley was not serious.

As soon as plans and profiles of the site were prepared several preliminary designs were made to determine the most economical design of floor system and arch span. The uniform live load and dead load were used in these calculations and only the bending moments for beams and slabs and compressive stresses on arch ribs and columns were calculated. Comparisons were made of the total yardage of concrete based on these preliminary designs, and the general type of structure was thereby determined. The floor system was compared on a basis of two, three and four beams running lengthwise of the bridge, with varying spans between cross-beams at columns. The short spans, while more economical in beam construction, were much more expensive in total cost due to increased number of column supports. The two and three-beam systems were found uneconomical on account of heavy floor slabs required.

In determining the general type of arch to be used the span and rise were practically fixed by the cross-section of the valley and required height of bridge. It was necessary to clear the street in the valley below and also to have abutments extend into rock foundations to eliminate the cost of expensive abutments. A span of 150 ft. was the minimum that would fulfil these conditions, but several greater trial spans were assumed. The result under the uniform live and dead load test showed that the minimum span was the most economical.

LOADINGS AND STRESSES

Having determined the general type of construction by these trial methods, a detail design was then made. The floor system, sidewalk system, and column supports were worked out in detail in the above order, followed by the analyses of arch ribs, abutments, and form work for arch. The following loadings and stresses were assumed:

Loadings.—Total dead load; uniform live load of 100 lb. per square foot; 20-ton road roller with no impact; two 50-ton interurban cars on double track with impact allowance of 25 per cent on beams and girders; 25 lb. wind load per square foot on side of bridge and moving load; and temperature stresses due to a variation of 40 deg. Fahr. on each side of construction temperature.

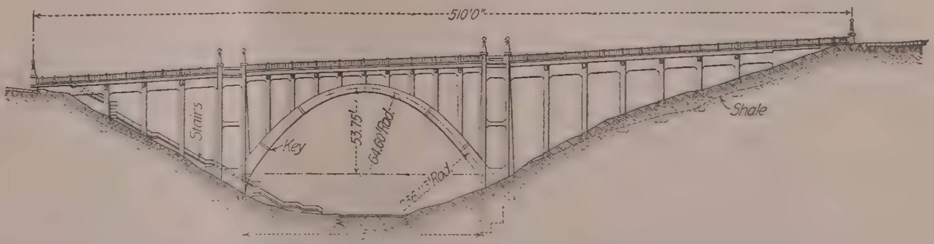
Stresses.—Steel in tension, 16,000 lb. per square inch; steel in shear, 12,000 lb. per square inch; concrete in compression, 500 lb. per square inch; concrete in shear, 35 lb. per square inch; concrete in shear reinforced, 100 lb. per square inch; and ratio moduli of elasticity, 15.

The straight-line formula was used in calculating deformation stresses on all beams, and the elastic-arch theory as developed by Cain was used in designing the arch ribs. This was checked by applying the modified elastic arch formula as developed by Wilkinson and Ferguson for the Pittsburgh reinforced concrete bridges.

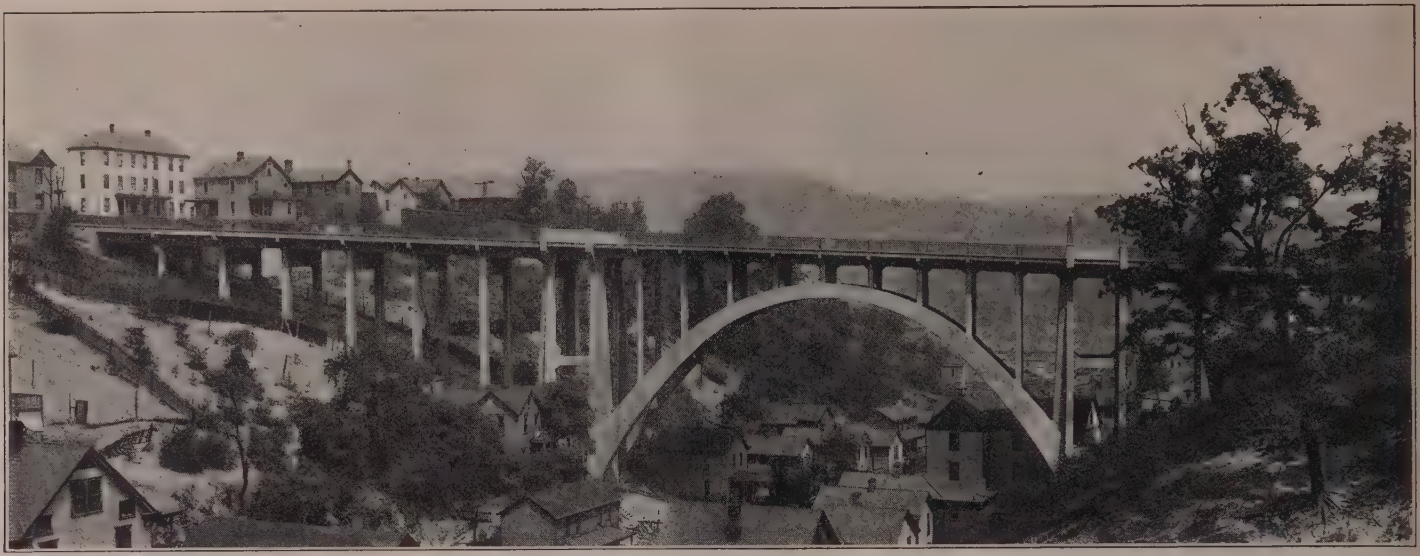
REINFORCEMENT

The reinforcement is designed on a basis of unit construction of one of the standard types, although a deformed-bar system is used in secondary beams and floor slabs where there is sufficient area to develop full strength for adhesion to the concrete. All shear members in main girders are required to be rigidly attached. The steel is shown on plans in terms of sectional area of standard square bars. The cantilever beams supporting sidewalk floor slabs are located at each line of columns and are built into columns. The space beneath the sidewalk slab and between supporting beams is arranged for carrying the electric conduits for the lighting system, which rest on the cantilever beams and are reached by cast-iron handholes located in the floor slab above.

In designing the arch ribs a 5-ft. thickness and sufficient depth at the crown to take care of the thrust at that point was



ELEVATION OF MONESSEN VIADUCT AND 150-FOOT MAIN ARCH



THE MONESSEN VIADUCT OVER DEEP RAVINE CONNECTS TWO IMPORTANT RESIDENTIAL DISTRICTS

assumed. The proper curvature and section were then found by first determining by the elastic theory the arch whose axis would coincide with the dead-load polygon, based on the dead loads obtained from the design of the floor system and from the assumed section of the arch. The parabola was then slightly modified by substituting a three-centered arch and the stresses were then determined for live load, rib shortening and temperature. The arch section was further modified so as to keep the maximum thrust within the middle third. The steel reinforcement was determined in the usual manner by determining the maximum moments at each panel point. The steel reinforcement was designed for a system of unit construction, with all shear members rigidly attached to main reinforcement as called for in the main girders. The maximum live load was obtained with uniform live load over the bridge and with two street cars placed over the quarter point. Balet's formulæ for determining the horizontal thrusts due to temperature changes and rib shortening were used, and the bending moments and axial thrusts were computed for the various panel points in the usual manner.

ARCH ABUTMENTS

The abutments for the arch ribs are designed to distribute the load from both ribs over a plane normal to the line of maximum thrust. The average loading on the foundation for abutment is 2 tons per square foot, which is low considering the character of foundation. The abutment consists of mass concrete to a point just above ground line.

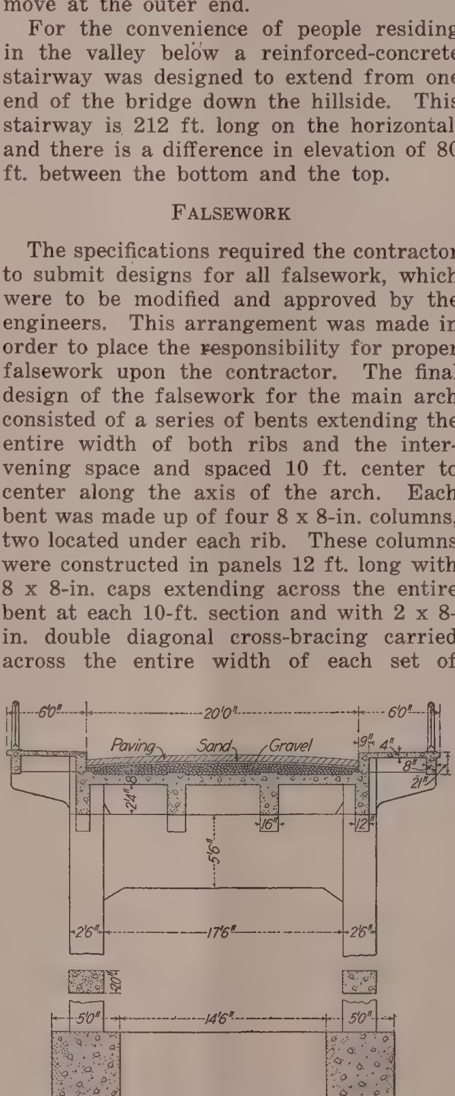
The columns supporting approach spans rest on solid rock. The footings are carried down to a depth of 6 ft. and well into the rock formation. The maximum loading on column footings does not exceed 20 tons per square foot.

Four expansion joints are provided for the bridge in addition to the arrangement for expansion provided for in the method of constructing the floor system and beam supports in unit sections with sliding joints. These main expansion joints are located at the points where the approach spans rest upon approach abutments and where the arch spans rest upon the main abutment piers. The design of the floor system is the same at these points as for the sliding joints of the unit sections, with the exception that bronze plates are provided under the supports of the beams. A space of 1 in. is left between adjacent sections of beams and slab, which is covered on the surface of the bridge with a cast-iron cover plate on the sidewalk and by a special concrete joint in the roadway. These four joints permit the roadway over the arch to move independently of the approach spans, and each approach span can move at the outer end.

For the convenience of people residing in the valley below a reinforced-concrete stairway was designed to extend from one end of the bridge down the hillside. This stairway is 212 ft. long on the horizontal, and there is a difference in elevation of 80 ft. between the bottom and the top.

FALSEWORK

The specifications required the contractor to submit designs for all falsework, which were to be modified and approved by the engineers. This arrangement was made in order to place the responsibility for proper falsework upon the contractor. The final design of the falsework for the main arch consisted of a series of bents extending the entire width of both ribs and the intervening space and spaced 10 ft. center to center along the axis of the arch. Each bent was made up of four 8 x 8-in. columns, two located under each rib. These columns were constructed in panels 12 ft. long with 8 x 8-in. caps extending across the entire bent at each 10-ft. section and with 2 x 8-in. double diagonal cross-bracing carried across the entire width of each set of columns; 2 x 8-in. diagonal cross-bracing was also carried across each 10-ft. panel between bents for each row of columns so as to afford rigid bracing of the entire falsework. The form for the base of the arch rib was designed to rest on five 2 x 12-in. pieces supported by columns and by an 8 x 10-in. strut spaced half way between each row of columns and braced to them by diagonal bracing.



SECTION SHOWING FLOOR SUPPORT

The arrangement for dropping the formwork consisted of oak wedges placed just above the second panel from the ground in between two 8 x 8-in. cross-pieces. A pair of wedges was placed between these cross-pieces under each column. The foundations for the columns consisted of concrete piers built especially for this purpose and extending to solid rock. Where the falsework rested on roadway pavement in the valley 4 x 8-in. sills 4 ft. long were placed under each column, laid on the pavement, and no concrete foundation was built. The stresses assumed in designing the falsework were 1000 lb. per square inch for tension and 1200 lb. per square inch for compression, and the length of columns was limited to fifteen diameters. The load to be carried was the entire weight of the arch rib divided into sections.

The formwork for the approach spans and for the main roadway over the arch was designed in the usual way for frame construction, and no special features were involved.

CONSTRUCTION QUANTITIES

The total amount of concrete placed in the bridge was 3036 cu. yd. In addition, 189 cu. yd. of concrete were used in foundations for supporting arch centering. This concrete and the concrete used for retaining walls, abutments and column bases consisted of 1 part Portland cement, 3 parts sand, and 6 parts gravel by volume. The rest of the concrete was in the proportion of 1:2½:5. The excavation for the permanent work consisted of 680 cu. yd. of earth excavation and 232 cu. yd. of rock excavation. In addition, there were 207 cu. yd. of excavation for the foundations for arch centering.

The contract price for the bridge, including pavement, was $50,600. This was increased to $52,500 by the extra excavation, the concrete required for foundations and the allowance for rock excavation.

The work was designed by Chester &

Fleming, engineers, of Pittsburgh, who also supervised the construction. The Nicola Building Company, of Pittsburgh, was the contractor and A. K. Hubbard, of Chester & Fleming, was resident engineer. The success of financing and launching the project was to a great extent due to Dr. R. H. Hunter, of Monessen, chairman of the bridge committee of the City Council.

Rebuilding a Bridge 500 Years Old

Replacing Ancient Masonry Arches of Notre Dame Structure Over the Seine in Paris by a Single Plate-Girder Arch Span

THE recent rebuilding of the Notre Dame Bridge in Paris is a notable circumstance in that it brings up to the twentieth century an engineering structure that was first put in service more than 500 years ago, and has since been rebuilt only three times, although in constant use. The present work is an example of progressive American methods and materials adopted in conservative European practice. It involved the removal of three short-span masonry arches in the center of the channel and the building in their place of a single plate-girder arch span erected on falsework trusses, the reinforcement of two pier shafts and their footings to resist the unbalanced thrust after the removal of the short spans and after the construction of the long span, and the widening of the old arch spans at the ends of the bridge. Bridge traffic and navigation were maintained throughout the construction. The old foundations were retained and enlarged and the serious obstructions offered by the center piers will be entirely removed, thus greatly improving navigation.

The Notre Dame Bridge across the Seine is a historic structure first built about the year 1400. It was destroyed by a flood in 1499, and was immediately replaced by a structure which endured until 1852, when a new superstructure was built on the old foundations. The piers were not quite parallel to the axis of the river, and, according to the "Génie Civil," from which this description has been prepared, they constituted a serious obstruction to navigation and caused numerous accidents. The bridge had five cut-stone arches of about 57, 61 and 62-ft. spans and a width of 71 ft. over all.

Alternative plans of reconstruction were considered, one of them involving a new center span of 284 ft. and the other a new span of 197 ft., retaining the two end arches. As the respective estimates of cost for these plans were about $252,000 and $157,000, and as the vertical clearance was inadequate for a satisfactory rise for the long-span arch, the second plan was adopted, and is now in an advanced stage of execution.

NEW SPAN

The new span has eight riveted plate-girder arch ribs, spaced about 8 ft. apart on centers, except the outer ribs, which are about 13 ft. from the next ones. The depth of the ribs varies from about 2.6 ft. at the crown to 3.9 ft. at the skewbacks, and the center line is a segment of a circle of 256-ft. radius, which gives a rise of about 20 ft. The ribs are connected by transverse lattice girders in radial planes. These girders have the same depth as the arch ribs at the point of intersection, and are spaced about 10 ft. apart. Vertical posts, also spaced about 10 ft., carry longitudinal and transverse girders supporting the 4 x 5-ft. buckleplates. Wood block pavement is used except under the electric-car tracks, where the concrete floor has an invert-shape cross-section supported on concave steel plates, affording clearance for the electric conduits. The outside girders are masked by cast-iron molded fascia bolted to them and joined at the crown to molded cast-iron cornice pieces.

The ends of the arch ribs are provided with cast-steel shoes in radial planes, and corresponding cast-steel pedestals are anchored to the masonry. Both shoes and pedestals are recessed to receive three full-length horizontal transverse keys with a rectangular cross-section, convex on the side toward the arch ribs, in which they have concave bearings. The keys are adjustable by shims on the skewback sides. The center keys were first inserted, and the ribs erected with them acted as two-hinge arches under dead load only. After the erection was completed and all of the dead load imposed, the other two keys, above and below the center keys, were inserted and adjusted to positive bearings, thus transforming the ribs to fixed-end arches under live load.

REINFORCING PIERS AND REMOVING ARCHES

Piers 1 and 4, carrying the river ends of the end spans, were originally proportioned for balanced loads from the nearly equal adjacent spans they supported. When the balance was disturbed, first, by the removal of the river spans and, afterward, by erecting the long new steel span, their sections became inadequate for the unbalanced stresses developed. They were therefore reinforced by extensions 10 ft. wide on both sides and by increasing the width and height of their shafts. The piers were inclosed by a cofferdam of Carnegie steel sheet piles 36 ft. wide. The interior of the cofferdam was excavated to the bottom of the old stone footing and was filled, nearly up to low-water level, with concrete thoroughly anchored to the old masonry.

The three center arches between these reinforced piers were wedged on falsework centers seated on timbers transverse to the axis of the bridge. They were supported on inclined posts seated on the old pier footings below water level and had their overhanging tops tied together by longitudinal horizontal rails on both sides of the bridge. This arrangement left nearly all of the space between the piers at water level unobstructed for navigation and permitted the removal of the old arches and piers down to the skewbacks. Subsequently the two center piers were removed, after having served for the support of the falsework for the erection of the new span.

The faces of the reinforced piers were racked off above the new footings and new stone-faced concrete was built over and around them, forming shafts reaching to roadway level between the new span and the old end spans. New cutwaters were built on the ends of the reinforced piers and both faces of the end spans were extended by new arch rings built out to give this portion of the bridge the same width as that of the new span.

ERECTION OF NEW SPAN

Cantilever brackets were built on one side of the bridge to carry the sidewalk temporarily, the vehicular and car traffic was confined to a narrow adjacent strip of the old structure, and the remainder of the three old arch spans was removed in one longitudinal strip having a width greater than one-half of the original width of the bridge. Afterward six wooden falsework trusses were set on the old piers in the panels between the new arch ribs, and the latter were erected on them by an overhead gantry traveler. Some of the vertical posts of the falsework trusses extended below the bottom flanges of the arch rib to carry a working platform below and parallel to the latter.

After the completion of the longitudinal section of the new arch, traffic was transferred to it, the remainder of the three old arches removed, and the balance of the new span built. The two old center piers are now being removed. The total cost of the reconstruction of the bridge is about $273,000.

Effects of Acids and Alkaline Solutions on Mortar

ACTION of ordinary ground water on concrete is generally checked by the film of carbonate which eventually forms at the surface of calcareous cement, provided that the mass is not too porous in the beginning, according to a statement in the report for 1913 of the Board of Water Supply of the City of New York. This, together with the compactness of the mortar, under ordinary conditions hinders the ingress and egress of the water and prevents ultimate destruction. But where sulphuric acid is present the lime or carbonate of lime constituent is converted into a soft, friable sulphate of lime (gypsum). The expansion attending this change causes small cracks which admit the acid water into the body of the structure. From a layer of moisture on the surface of the concrete the acid enters fine cracks and is diffused by capillarity through the pores of the mass. A constant repletion of the dissolving medium leads in time to its continual passage through the structure. Where the action of the water is ceaseless and the acid supply, however dilute, exhaustless, the aggregate effect is large. Unless means are found for diverting the flow of such waters, or adequate protection in the form of an impermeable coating is furnished, damage of the most serious nature will be the inevitable result. Nor can it be foretold how quickly such damage may supervene. At Osnabrück, Prussia, a concrete sewer built in ground water containing less than 100 parts per million (about 6 grams per gallon) of free sulphuric acid showed signs of destruction in two or three years.

Ground waters highly impregnated with soluble sulphate attack and dissolve certain of the calcium compounds of set cement, robbing the mortar of its cohesiveness and strength. In the absence of unusual density or of some effective method of protection, the destruction, while not so rapid, is just as complete as in the case of acid waters. Experiments have shown deterioration to be most marked in the case of magnesium sulphate acting in the presence of sodium sulphate, both of which salts have been found occurring together in some of the waters of the city tunnel shafts. Dense, impermeable concrete, however, resists such attacks well.

WATER-BOUND MACADAM is being used in the Panama-Pacific Exposition for most of the streets and driveways, the total wearing surface of which is about 444,000 sq. yd.

WASH-WATER TROUGHS EQUIPPED WITH SAND CATCHERS

Water-Purification Plant at Flint

Mushroom Growth in Population Surrounded Old Plant and Forced Michigan Automobile City to Rebuild Waterworks at a New Site

GROSS pollution and lack of capacity to meet typical boom town conditions forced Flint, Mich., to rebuild its whole waterworks system beginning in 1910. From a few thousand in 1900 the advent of automobile manufacturing establishments increased the population to 38,500 in 1910, and to about 40,000 at present. The average consumption now is 5,000,000 gal. daily, with a maximum of 6,500,000 gal. The town grew above the waterworks intake, taking water from the Flint River, until the drainage of 5000 persons became tributary to the stream above the intake, causing serious pollution in addition to heavy turbidity. Reports were made indicating that a well supply was not feasible and that the cost of going 11 mi. to a lake supply was larger than was justifiable in view of the fact that the lake supply would probably have to be filtered. Finally the new plant was located on the Flint River, 1½ mi. above the old one and about 2½ mi. north of the central part of the city.

In general the plant comprises a pumping station for both high and low service, eight 1,000,000-gal. daily mechanical filters, 3¾-hr. settling capacity, a 2,000,000-gal. clear well under and at the end of the filters, pump and boiler house, stack and intake. Some of the newer features in the filter plant are the arrangements for blowing out sand from the air-wash system, an automatic unloading sand catcher on the wash-water troughs, solution agitators with small-diameter propellers and flexibility in the baffling arrangements of the mixers and settling basins.

INTAKE AND SUCTION WELL

Water passes from the concrete wing-wall intake structure, containing two 42 x 42-in. sluice gates, by gravity through 433 ft. of 48-in. brick conduit to a suction well located just east of the pump house. The well is 16 ft. in diameter, 31 ft. deep and has a wall of reinforced concrete 16 in. thick. The invert of the intake line enters 4 ft. above the 9-in. concrete floor and the bottom of the single 42-in. suction leading to the pumps is at the same elevation. The latter line passes through the shell of the well 12 ft. above the floor just below normal water level, so that the line will ordinarily be full of water when the pumps are not working.

Baffling to obtain a maximum amount of agitation, following the addition of chemicals, is provided for in the Flint plant. The four compartments comprising the mixers are each 45 ft. long, 3 ft. wide and 18½ ft. deep. The water line is 18 in. below the top of the 16-in. walls. These walls are braced transversely by five 12-in. concrete struts reinforced to act also as ties. In addition the braces form under-and-over baffles between the adjacent struts to increase the rate of flow to 1½ ft. per second.

Gates in the inlet and outlet chambers permit various methods of operation to vary the velocity at will.

SEDIMENTATION BASIN

Two settling basins, each 68 x 103 ft. in plan and 12½ ft. deep, are constructed with reinforced concrete side walls, 7-in. slab roofs and very shallow, wide girders, giving a panel effect. The girders extend 8 in. below the slab, but they are 3½ ft. wide. Economy of space was sought, but the engineers state that the saving by shortening the slab span compensated somewhat, if not entirely, for the less economical shallow girders. Dimensions of the bay, 17 ft. 4 in. center to center of columns, came from the filter units and were made uniform throughout. Loading consists of 18 in. of earth, but no damage was done by the operations of a 10-ton roller on top of the earth.

Each of the 16-in. square columns is grooved on all four sides to receive wooden baffles, so that in the future any possible method of baffling desired may be attained. At present the baffles are arranged to give a flow around the end with a nominal velocity of the water at 8 ft. per minute. In construction the reinforced column bases, 5 ft. square, were built independent of the floor slabs and the construction joints were filled with asphaltic pitch for water tightness. Leakage on test amounted to less than ¼ in. in depth per day.

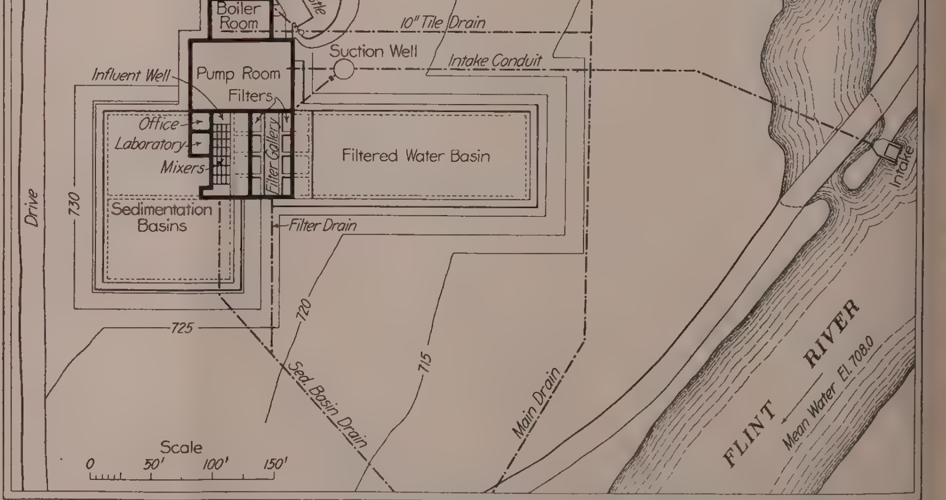
FILTERS

Four filters, each having a filtering area 16 x 22½ ft., are placed each side of the 12-ft. pipe gallery. They consist of 16 x 24-ft. concrete boxes 7 ft. deep, of the usual type, with a concrete wall near the gallery end forming a wash-water gutter to receive the discharge from the three concrete wash troughs. The top of this wall is 1½ in. higher than the steel weirs in the troughs. A special dumping sand catcher is hung over pins in angles on the sides of the troughs. The plates did not operate until the supports were made in the form of a hook, so that no sand would remain in the bearings. The troughs are designed to take a 15-in. vertical rise of wash water. They are supported by ¾-in. U-shaped embedded rods provided with turnbuckles to obtain level weir edges.

The underdrains consist of a cast-iron manifold laid down the center of the filter, and into which 2-in. cast-iron pipes are leaded at 6-in. intervals. Pittsburgh strainers are tapped into the laterals on 6-in. centers. Above the laterals are 10 in. of graded gravel supporting 30 in. of Cape May sand having an effective size of 0.41 mm and a uniformity coefficient of 1.51.

Innovations in the air system comprise three 3-in. brass headers, one of which opens into the pipe gallery, where it is closed by a valve, the idea being to provide means of blowing out any set of the ½-in. brass laterals. The mains are laid along the outer walls of the filter and the blowoff is in the center. The laterals are screwed into the headers at both ends. The system is located near the top of the gravel layer and the two rows of the 1/16-in. holes are drilled 45 deg. apart. The holes are staggered and turned down.

One of the photographs indicates the free space in the pipe gallery with the concrete



PLAN OF GROUNDS AND BUILDINGS, FLINT CITY WATERWORKS

PIPE GALLERY—CONCRETE INFLUENT ABOVE AND DRAIN BELOW

OPERATING FLOOR DEPRESSED BETWEEN FILTER WALLS

influent above, the drain below and the controllers at each side. The wash-water pipe is hung in the clear well below the gallery floor.

The rate controllers have a range of from 500,000 to 1,500,000 gal. daily each. In the original designs the range was between the minimum flow from a filter and 1,000,000 gal. daily. At the suggestion of the engineers the diaphragm was slotted and an auxiliary plate similarly slotted set over the diaphragm. By twisting the auxiliary plate the larger variation in the controlled rate may be effected.

HOODED CHEMICAL AGITATORS

All chemical-solution tanks and orifice boxes are of concrete in duplicate. Very small propellers on the agitators are placed near one end of each tank within a hood, the lower edge of which is close to the floor. The upper end terminates in a pipe discharging horizontally. One ½-hp motor operates two of the propellers through a belt-driven shaft at the rate of 206 r.p.m.

Following the practice of Davenport and Rock Island 1-in. rubber hose is used to convey the chemical solutions. The hose is easily cleaned by pounding, and the point of application in the mixing chamber can be changed at a moment's notice.

OPERATION

Operation is controlled by a chemist and bacteriologist, who has a fully equipped water-analysis laboratory, where samples taken daily are examined. From a report showing efficiencies from Aug. 30 to Dec. 14, 1913, when the bacterial content of the raw water was low, there are taken the following results: The raw water averaged 388 bacteria per cubic centimeter, with a maximum of 2170 and minimum of 70. The effluent ranged from 2 to 15 and averaged 6 bacteria per cubic centimeter. Lactose bile and Drigalski medium tests for B. coli were positive in all 1-cu. cm. samples of raw water and negative in the filtered water with a single exception. Color of the raw water averaged 51 p.p.m., varying from 29 to 100. The filtered water contained an average of 14 and ranged from 0 to 48. Turbidity of the raw water ranged from 2 to 90, with the exception of one day, when it reached 250. Almost uniformly the effluent turbidity was nil. As this was during the tuning-up period, coagulant application varied considerably, and for a three-week period, with the turbidity 15 or less, no coagulant was applied. When used it ranged from 0.5 to 4 grains per gallon, and averaged 2 grains.

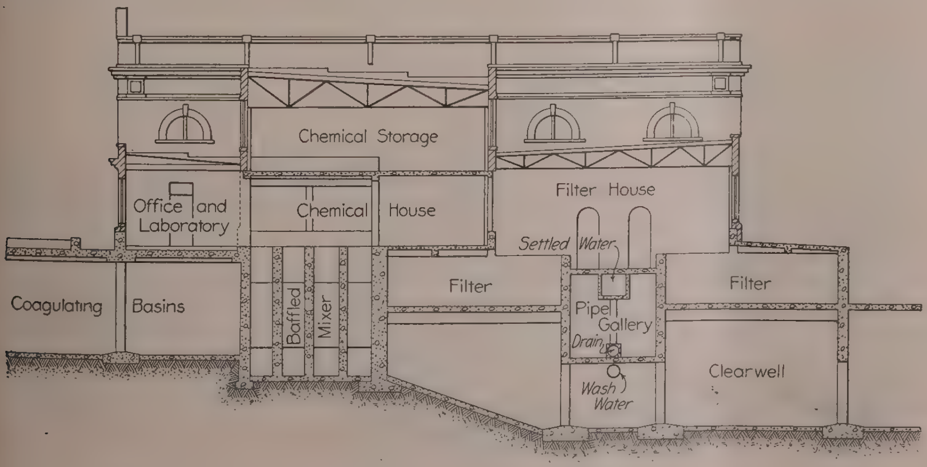
Later results, from Jan. 25 to April 14, show a bacterial removal of 99.56 per cent from the original 3560 average count, with average maximum and minimum number in the effluent of 150 and 0 respectively. The raw water ranged between 15,750 and 78. B. coli was present in all 1 and 0.1-cu. cm. samples of raw water and absent in all 1 and 10-cu. cm. samples of the effluent with a single exception. Turbidity ranged between 10 and 350 in the raw and was zero in the effluent. Color in the river water ranged between 12 and 50, while that in the filtered water averaged 8 for January, March and April and 11 for February.

PUMPING-STATION EQUIPMENT

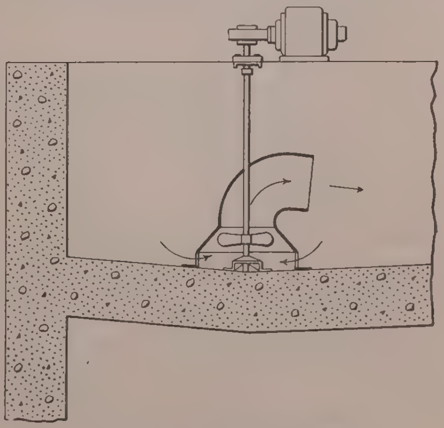
Connected with the 5 x 134-ft. Heinicke radial-brick stack are three 250-hp Wickes boilers with steel-incased settings. In the machinery room is a new 12,000,000-gal. daily horizontal cross-compound crank and flywheel Snow pump, which gave under test a duty of 145,000,000 ft.-lb. per 1000 lb. of steam. Taken from the old station are two units used as standbys, a 7,000,000-gal. daily cross-compound crank and flywheel Laidlaw-Dunn-Gordon pump and a 4,000,000-gal. daily Holly tandem compound duplex. One of the boilers was also brought from the old station. The two low-service units and one wash-water pump are interchangeable. They are DeLaval centrifugals connected by gears to steam turbines. A DeLaval steam turbine, a duplicate of the pumping turbines, drives a 35-kw Crocker-Wheeler generator furnishing electricity for lighting and incidental use. A Roots No. 2 blower furnishes 1100 cu. ft. of free air per minute at 4 lb. pressure, or 700 cu. ft. at 6 lb.

CONSTRUCTION

A siding about ¼ mi. long was constructed from the Pere Marquette to a concrete plant alongside the station site and ultimately was laid to the coal trestle. Concrete materials were unloaded from the cars by an Andresen-Evans 1-yd. bucket operated on an inclined overhead trolley spanning the car tracks, a storage pile at one side and elevated bins on the other side. Concrete ingredients were Universal Port-



CROSS-SECTION OF MAIN BUILDING, CHEMICAL STOREHOUSE AND FILTER HOUSE



SOLUTION TANK AGITATOR

land cement and sand and gravel obtained by rail from Rochester, 40 mi. distant. A Milwaukee mixer was located at the foot of a 170-ft. Smith tower, from which chutes carried the concrete to the forms on inclines not flatter than 1 to 5 slopes, a maximum distance of 400 ft. A separate American hoisting engine operated the Smith buckets in the tower. Two auxiliary distributing towers were erected within the neat lines of the plant.

PERSONNEL

William G. Clark was the consulting engineer for the Flint Board of Water Commissioners from the inception to the completion of the new plant, which was reported upon in 1910 and formally placed in operation by wire by President Wilson on Jan. 22. W. E. Baumgarder, W. E. Condit and W. C. Jones were resident engineers, reporting to the consulting engineer. William L. Fisher is superintendent of waterworks and Royal S. Buzzell is bacteriologist and chemist in charge of the filtration plant.

The general contract was held by the Pittsburgh Filter Manufacturing Company and much of the filter equipment is of its standard design. A. Bentley & Sons Company was the subcontractor for the building, concrete work, intake and outside piping.

Wheel-Tax Street-Repair System in Chicago

Abstract of Address Prepared for Cook County Road Society by J. L. Jacobs, Efficiency Engineer in Charge, Chicago Civil Service Commission

INTEREST in Chicago's wheel-tax road-maintenance system, heightened by a 50-mi. inspection trip on July 30, has inspired an article written by J. L. Jacobs, efficiency engineer in charge, Civil Service Commission, Chicago, for the Associated Good Roads Organization of Cook County. While many of Mr. Jacobs' comments are a repetition of what has been told of that trip in the Engineering Record of Aug. 8 (Current News) and Aug. 15, page 195, what follows is a reprint of new data from his article.

That the administration of the wheel-tax law has shown greater efficiency year by year is due in great measure to the effort made to keep the taxpayers in touch with the machinery. This law requires payment of annual fees by all users of vehicles, the revenue being devoted to repair and maintenance of city pavements which have outgrown the guarantee period. When repeal of the measure was being pressed upon the State Legislature several years ago the need for publicity was recognized, and the first step, of which the recent inspection tour is a successor, was taken to gain public confidence. The co-operation of road associations and civic bodies obtained then has permitted constant improvement in administering the law.

The plan by which the Department of Public Works, assisted by the efficiency division of the Civil Service Commission, executes this work provides that the city be treated as a unit and that expenditures from the fund be restricted to repairing permanent pavements and oiling, screening and repairing macadam pavements on main thoroughfares and through routes, based upon definite standards or schedules which take into consideration the condition of pavements and other controlling factors.

In the accompanying table are given the amounts collected each year since the passage of the law in 1908, as well as the amounts paid out. It will be noted that collections have steadily increased and that the 1914 collections up to July 1 total $650,000, showing a healthy increase over the collections for the first half of any of the previous years. The increased collections are largely the result of more thorough investigation on the part of the vehicle bureau of the police department and better co-operation between the city collector's office and the police department. While the records of the city collector's office and the department of police show this increase, investigation in the field, however, discloses an appreciable percentage of vehicles still going about without licenses. But with the continuing efforts on the part of the good roads organizations, the department of police and the city collector's office, it is estimated that the wheel-tax fund should be increased to at least $750,000 this year and to $850,000 or $900,000 next year.

WHEEL-TAX DATA FOR SIX YEARS

Year	Collections	Expenditures
1909	$500,186	$484,359
1910	560,213	506,058
1911	586,157	561,212
1912	596,832	547,969
1913	661,216	705,326
1914	*650,000	*450,000

*To July 1.

A comparison of the expenditures from the funds in 1910 and in 1913 gives the following approximate figures: In 1910 100,000 sq. yd. of asphalt pavement were kept in good condition at an average cost for repair of $1.17 per square yard and an average cost for maintenance of 6.9 cents. In 1913 the costs for 150,000 sq. yd. of asphalt were 81 cents per square yard for repair and 3.4 cents for maintenance.

The costs for caring for 54,000 sq. yd. of brick pavement in 1910 were $1.01 per square yard for repair and 6.9 cents for maintenance. In 1913 a similar area was repaired at an average cost of $1.17 per square yard for repair and of 5.2 cents for maintenance.

Approximately 65,000 sq. yd. of granite-block pavement were treated in 1910 at a cost of 60 cents per square yard for repair and of 11.5 cents for maintenance. In 1913 60,000 sq. yd. of granite-block pavement were repaired at the cost of 53 cents per square yard for repair and of 4.3 cents for maintenance.

During the years 1909 to 1914 on the average 1,500,000 sq. yd. (in length 85 mi.) of macadam have been maintained each year at costs varying from 12 cents to 16 cents per square yard. In addition, from 5,000,000 to 6,000,000 sq. yd. (280 to 350 mi.) of macadam have been oiled each year at costs varying from 6.4 cents to 2.15 cents per square yard.

The distribution of the $450,000 expended up to July 1, 1914, was given on page 195 of the Engineering Record of Aug. 15. A portable asphalt-repair plant belonging to the city was also described there. According to Mr. Jacobs, appropriations have been provided and specifications prepared for another portable plant for the utilization of old asphalt top, which heretofore had to be transported and discarded at a large cost. Old asphalt will be brought to this plant, crushed and reheated with new material and taken back to the job to be used as binder. In this way the expense of long haul and the waste of old material will be materially cut down and the capacity of work will be proportionately increased.

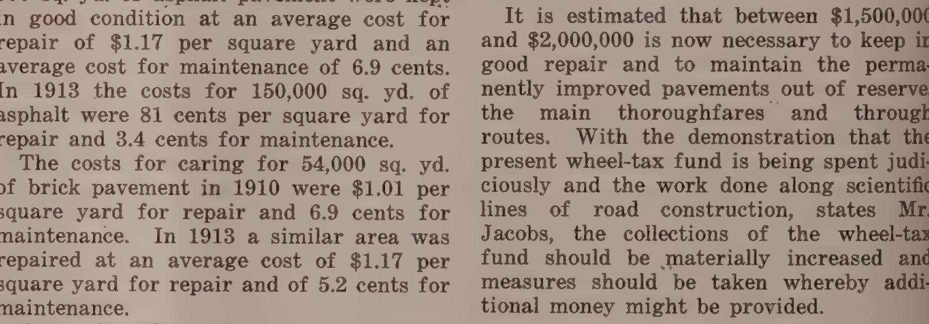
In closing, the article urgently advocates increasing the receipts from the wheel tax. The through routes indicated in the 1914 appropriation ordinance to be resurfaced approximate 61 mi. of roadway, which at an estimated unit cost of $8,000 will call for an expenditure of $480,000. In addition there are about 450 mi. of macadam, of which 55 mi. are on traction streets and other main thoroughfares which must be kept in good repair and maintained by oiling.

Aside from the macadam, the asphalt pavements out of reserve increased from 90 mi. in 1910 to 250 mi. in 1913, brick pavements, from 35 mi. to 70 mi., and granite-block pavements, from 20 mi. to 45 mi.

It is estimated that between $1,500,000 and $2,000,000 is now necessary to keep in good repair and to maintain the permanently improved pavements out of reserve, the main thoroughfares and through routes. With the demonstration that the present wheel-tax fund is being spent judiciously and the work done along scientific lines of road construction, states Mr. Jacobs, the collections of the wheel-tax fund should be materially increased and measures should be taken whereby additional money might be provided.

Catskill Aqueduct Bridges

TWO reinforced-concrete highway bridges with 175-ft. segmental arch spans of 25-ft. rise and 24 ft. wide between parapets have recently been built at Ashokan, Ulster County, under the direction of the Board of Water Supply. They are of the Melan type of construction, with concrete balusters and finished exposed surfaces. They were built by Ward & Kelly, Inc., contractors, under the direction of J. Waldo Smith, chief engineer.



REINFORCED-CONCRETE BRIDGE OVER ASHOKAN RESERVOIR SPILLWAY

Concrete Pavements and One-Course Concrete Curbs

Design and Methods Employed in Model City for Employees of Minnesota Steel Company at Morgan Park, West Duluth

To facilitate curb construction the usual mortar surface is omitted in building the concrete curbs alongside the concrete pavements in Morgan Park at West Duluth, Minn. Like "Spotless Town," everything possible will be sanitary, imperishable and fireproof, for Morgan Park, popularly called the "Model City," will house the employees of the Minnesota Steel Company. About 170 hydrostone houses, of which ninety are apartment houses, in two to six-flat units, will be ready for occupancy this fall. In July about 100 houses were completed, a few were occupied and work was progressing on all of the others. Work on concrete street paving, curbs and sidewalks, which are all of the one-course type, was well under way.

The paving work follows the standard specifications of the American Concrete Institute for one-course work with triangle-mesh reinforcing. In construction the sub-base was compacted by an Austin 10-ton roller and the concrete laid by a ½-yd. Marsh-Capron mixer traveling by its own power on planks over the sub-base. A Roughen adjustable strike board, which rides on the curbs, gives the 3-in. crown. Every 30 ft. Trus-Con expansion joints are inserted with a ½-in. Elastite joint along each curb.

Handling Aggregate in Industrial Cars

Aggregate of sand and broken stone for all of the work is brought to the site in standard-gage cars and unloaded at the head of each of the four-block streets. From the stock piles narrow-gage industrial tracks are laid down each street just inside the curb. Three spurs of the standard-gage track are extended down the alleys in three of the sets of blocks to facilitate handling the concrete blocks and material for the houses. The blocks are made at the cement-products plant of the Minnesota Steel Company, ½ mi. away.

Wooden forms and Blaw-steel forms are used in constructing the one-course 16 and 22-in. curbs. Quite a little experimentation was indulged in before the present wood forms for the deeper curbs were evolved. The curb section is 9 in. wide at the bottom, 6 in. at the top and 22 in. deep with the batter on the back side. The forms are stripped within 3 hr. after depositing the concrete, which is mixed fairly wet in a Standard or a Broncho mixer, driven by a gasoline engine located in the roadway. The face, top and part of the back are rubbed and brushed to remove the form marks, but no attempt is made to secure the usual troweled finish.

FORMS FOR ONE-COURSE CURB

Lining Up Forms

For ease in lining up the side forms, which are made up of three 2 x 8-in. planks shod on the ends with steel strips, three ⅝-in. steel dowels 1 in. long are provided in the ends. Four 2 x 4-in. cleats hold the three 2 x 8-in. planks together. To set the forms, 2 x 4-in. stakes are driven into the ground and braced at 3½-ft. intervals. Wood spacers of 2 x 4-in. blocks are placed in the bottom and small 1-in. sticks at the top. Spreading of the top is prevented by U-clips of ½ x 2-in. steel. Every 5 ft. a strip of Elastite is inserted and held in place by 1½ x 3/16-in. steel strips inserted in slots cut through the form at the top and half way down.

Forms of wood were provided for about 600 ft. of curbing. An equal length of steel forms was used. The curb-setting crew comprised twelve men segregated as follows: Two finishers, one foreman, two laborers and two form setters. With this crew the usual progress was 380 ft. per day, with the maximum day's work, up to July 15, of 650 ft.

The work is being done by Butler & Coons, of Hibbing, Minn., who have the contract for all of the paving and sidewalk work. Morell & Nichols, of Minneapolis, are the engineers in charge. C. F. Myers is resident engineer for Morell & Nichols and George Ritchie is the inspector. Walter Buehler is in charge of the work for Butler & Coons.

INDUSTRIAL TRACK INSIDE OF CURB TO CLEAR MOUNTED STRIKE BOARD

Rapid Water Pipe Trenching

Excavating 10 Feet Deep for a 4-Foot Pipe Line in Hard Ground with Steam Shovel—Progress 175 Linear Feet Daily

The municipal water supply for Staten Island or the Borough of Richmond, New York City, will be supplied from the new Catskill Aqueduct by a submerged 4-ft. cast-iron pipe line extending across the Narrows and thence a mile overland through the streets to the Silver Lake reservoir. A large portion of the latter part of the line is now being laid in a trench 5 ft. wide and about 10 ft. deep that has been excavated through hard ground and rotten rock by a Bucyrus steam shovel with a ⅞-yd. bucket. The shovel is mounted on traction wheels and travels over the completed trench on a platform made of 10 x 12-in. transverse timbers about 20 ft. long laid on the surface of the ground. The timbers are picked up in the rear and laid down in front as the shovel progresses. The width of the trench is just about great enough to give sufficient clearance for the bucket which swings down with an almost vertical handle and after filling is dumped into two-horse wagons alongside.

Generally all of the preliminary work necessary is the removal of a few paving stones forming part of the gutter at the road side and extending partly across the width of the trench. In some cases a narrower and shallow preliminary trench had to be dug for the removal of existing pipes and connections, but it hindered rather than facilitated the shovel work. The bucket readily excavated through the macadam road surface and left the hard, dry soil standing with vertical faces until lightly braced by sheeting boards. In the partly disintegrated soft rock the excavation was made without blasting.

A force of six steam-shovel men and two followers to attend to the bracing and sheeting has accomplished an average amount of 175 lin. ft. of trench per day. The work is being executed by the Beaver Engineering & Contracting Company, under the direction of the Board of Water Supply, City of New York, of which J. Waldo Smith is chief engineer.

Steel rails from Calcutta are expected to be received presently in San Francisco. They will be made at the works recently designed and constructed by Julian Kennedy, Sahlin & Company, Pittsburgh and Brussels, which were recently put in commission. Its competition with American steel mills is possible because the plant has a raw material freight rate of 3 mills per ton per mile, pays women pig-iron carriers 6 cents and common laborers 9 cents per day, which is 50 per cent higher than previous labor wages in that district. The entire payroll for the 7000 natives employed in the plant is only 5 or 10 per cent less than that for the 159 Europeans there.

Testing Low-Head Turbines by Chemical Method

Titration Used Successfully in Measuring Discharge Through an Eight-Runner, 7200-Horsepower Waterwheel Set in an Open Flume

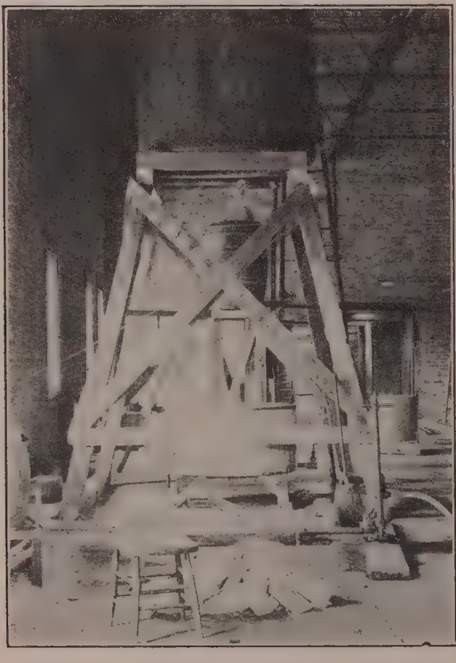
By ABRAHAM STREIFF, C.E.
Fargo Engineering Company, Jackson, Michigan

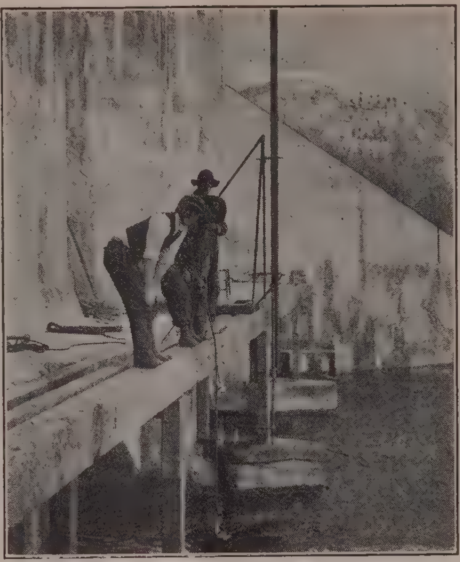
THE water consumption of a 7200-hp horizontal, eight-runner water-turbine, running at 225 r.p.m. and operating under a head of 39½ ft., was measured by the chemical method during the week of May 11. The wheel is located in the Croton development of the Grand Rapids-Muskegon Power Company, which was described in the Engineering Record of Oct. 19, 1907, page 418. The entire installation consists of two units of the same type. The water consumption was found to be 2140 sec.-ft. per unit.

In the Engineering Record of Jan. 31, 1914, page 143, there was an article by the writer describing in detail the method of water measurement by the salt-solution (titration) method, and in the issues of Aug. 22 and 29, 1914, pages 208 and 246 respectively, B. F. Groat dealt exhaustively with the same subject. This method has been successfully applied, as therein mentioned, on high-head turbines with small discharges. Recently it was tried at the power plant at Ventavon, France, on Francis turbines in a closed flume and pipe line, where the salt solution was injected at the intake of the pipe line. The solution had to travel throughout the length of the pipe line and through the turbines, where it was thoroughly mixed, giving results that were successful in establishing the adaptability of the method for larger discharges.

A test on open-flume turbines with large water consumption, however, has never been made heretofore, and there existed a well-founded doubt as to the feasibility of obtaining a perfect mix between the salt solution and the discharge water of the turbines.

For testing the Croton plant current meters of the screw type (Epper-Ott) were used. These meters are recognized in Europe as being accurate, but heretofore have been little used in this country. Not being able to install a weir for such large quantities of water, because of its cost, it was desirable to use some other means of water measurement in order to check up the results as obtained by the current meters, and the titration method was selected.


TANKS FOR INJECTING INITIAL SOLUTION


SAMPLING WATER IN TAILRACE

ARRANGEMENTS FOR TEST

The same detailed arrangements of the titration test were carried out according to the advice of Dr. Leon Collet, director of the Swiss Hydrometric Bureau, to whose investigations we are indebted for the knowledge of the accuracy obtainable by the titration method. In the case of the Croton water-power plant the difficulty was principally in obtaining a perfect mix. The draft tubes are rather short and adjoin a widening tailrace, necessitating the taking of samples of the mixture no farther downstream than at the end of the draft tube. The salt solution was injected directly into the turbine, and the photograph shows the arrangement of the tanks on the penstock deck containing the salt solution and the pipes leading to the four nozzles used to discharge the solution under a constant head.

The results have been successful. It was found that a perfect mix was obtained, notwithstanding the fact that the salt solution was injected no further than 40 ft. away from the place where the samples were taken in the tailrace, and the analysis showed that the percentage of salt in different samples of the mixture did not vary more than 1 per cent from the average of all samples. Although this is not quite as good a result as has been obtained heretofore with smaller discharges and greater length of mixing, it is sufficient to show the possibility of obtaining a perfect mix also in low-head plants.

The final calculations showed a difference of 1.3 per cent with the results as obtained by the Ott meters. This, however, is not entirely due to the conditions of the test, but must be ascribed in large part to the difficulties encountered in the titration method. Due to the dark color of the water, it was not possible to distinguish the color test as sharply as could have been done in places where the water is clear—as, for instance, in the test conducted by Dr. Collet.

On the whole, the test proved conclusively that the titration method is a practical, accurate and swift method of water measurement for the testing of low-head turbines with large water consumption. The tests were made by the Fargo Engineering Company, of Jackson, Mich.

Leakage Tests of Catskill Aqueduct

Experiments Show That Percolation of Water Through Walls of Conduits Takes Place Almost Entirely Through Expansion Joints

TWENTY-SIX portions of standard cut-and-cover and four portions of reinforced-concrete sections of the Catskill Aqueduct have been subjected to leakage tests by the Board of Water Supply of the City of New York. The portions of standard cut-and-cover aqueduct averaged 270 ft.; the longest was 409 ft. and the shortest 196 ft. Every variety of cut-and-cover aqueduct and almost every kind of foundation encountered during construction were represented.

The same general method of conducting the tests and measuring the leakage was followed in nearly all cases. Substantial bulkheads of timber and sheathing or of brick masonry were erected at the two ends of the test section and made as nearly watertight as practicable. Water was then admitted until a depth of about 16 ft. on the invert was reached, when the inflow was stopped and the water permitted to subside. The elevation of the water surface was determined several times a day until it reached a depth of from 8 to 10 ft. or until it ceased to fall. In a few cases the water surface was held at a fixed elevation by regulating the inflow, which was measured as it passed through a small tank of known capacity, the volume passing in a given period being taken as the total leakage for that period. To measure the leakage through the bulkheads, for deduction from the total, a small tight dam was built outside of each with a short piece of pipe just below the crest, out of which the leakage through the bulkhead was compelled to flow.

GENERAL DEDUCTIONS

Reports of the hydrostatic test, together with those of micrometer measurements of the seasonal variation in width of expansion-joint openings, were carefully reviewed to discover laws governing the leakage in the aqueduct. According to the 1913 report of J. Waldo Smith, chief engineer, only the most general deductions can be made. Hydrostatic tests were made in cold weather, at times when the joint openings, and therefore the leakages, were greatest. In a number of cases the same sections of aqueduct were subjected to several retests—first, two or more tests before grouting expansion joints, then one test after grouting invert expansion joints, one after grouting side-wall and arch expansion joints, and, finally, one or more after a lapse of a year or more.

Direct measurements of arch expansion-joint openings were made by spanning with a micrometer, reading to 0.001 in.; two nails were carefully set in the concrete, one on either side of the joint. Most of these readings were taken at the waterway surface at two or three elevations, but there were a few readings taken at the external surface and by means of cavities excavated at the joints, some midway between the outside and inside surface of the aqueduct. These joints were examined at irregular intervals for periods varying from 12 to 30 months, the temperature of the air both outside and inside the aqueduct being observed.

As would be expected, the most important factor causing variation in joint opening, and therefore in leakage, is the difference between the temperature of the concrete at the time it was placed and that at the time of making the test. Whenever the latter temperature was higher than the former, the joints were comparatively tight. Under the reversed conditions the greater openings or leakages occurred with the greater differences. The temperature factor was so great that all other factors were obscured by it; yet those other factors were of enough influence to prevent the deduction of the law of relation of leakage to temperature difference. The following statements, however, may be confidently made: (1) Leakage from the cut-and-cover aqueduct is almost entirely through the joints—i. e., very little through the concrete mass or elsewhere than at the expansion-joints; (2) there is a progressive diminution in the amount of leakage with lapse of time entirely independent of temperature influence; and (3) the method of stopping leakage through the expansion-joints by filling with Portland cement grout is satisfactory, effective and permanent.

Gasket for Joints

THE problem of durably tight joints was paramount in the design of the pipe castings adjoining the 66-in. diameter section valves in the city tunnel of the Catskill Aqueduct, according to the 1913 report of the Board of Water Supply of New York City. Research did not reveal any gasket satisfactory for the purpose except wire cloth coated with red-lead paste. After experiments in the laboratory, it was decided that two layers of 40-per-inch mesh bronze wire cloth coated heavily with red lead would make a satisfactory gasket, if the paste were allowed to set properly. The alternative was ground joints; but no precedent for them with diameters of more than 30 in. could be found. It was decided, however, that if a 30-in. joint could be made successfully, 8-ft. joints could be also, and as a result they were specified for some of these castings.

Difficulties in Building Reinforced-Concrete Aqueduct 17 Feet in Diameter

Huge Monolithic Structures at Kensico Reservoir of New York's Catskill Waterworks Involved Unusual Construction Problems

By GEORGE T. SEABURY
Formerly Principal Assistant Engineer, Kensico Division, Board of Water Supply

ONE of the many problems involved in building the Catskill Aqueduct, by which New York City's new water supply is to be made available, was the construction of a 3-mi. stretch of cut-and-cover conduit capable of carrying 500,000,000 gal. daily under a head of 29 ft. The size of the conduit necessary, because of the allowable gradient, precluded the use of a steel lining, unless that lining were to be assembled in the field. The cost of such a lining would have been a considerable factor. The head that will obtain made a reinforced-concrete structure quite possible, and the necessity of insuring against a deformation that would be sufficient to cause a longitudinal crack and subsequent leakage determined that it be circular in shape. A concrete conduit 17 ft. in diameter and with reinforcement consisting of a pair of rings was evolved.

This massive and relatively simple structure nevertheless possessed some features that rendered its construction particularly difficult and slow. An analysis of the construction details and some of the attending difficulties may be of value both to designers in their study of the elements that cause trouble and to constructors in their efforts to attain the desired result satisfactorily and at a practical cost.

The effluent aqueduct, so called, is the conduit leading from Kensico reservoir toward the proposed filters. Lying along the margin of the reservoir is the bypass aqueduct. It is similar in design to the effluent aqueduct, but because a steeper gradient is possible the bypass aqueduct is only 11 ft. in diameter and is less heavily reinforced. Through the bypass aqueduct flow to the city may be maintained without the use of the reservoir. The construction problems were common to both structures, but as they were more difficult in the larger conduit attention is here confined largely to that structure.

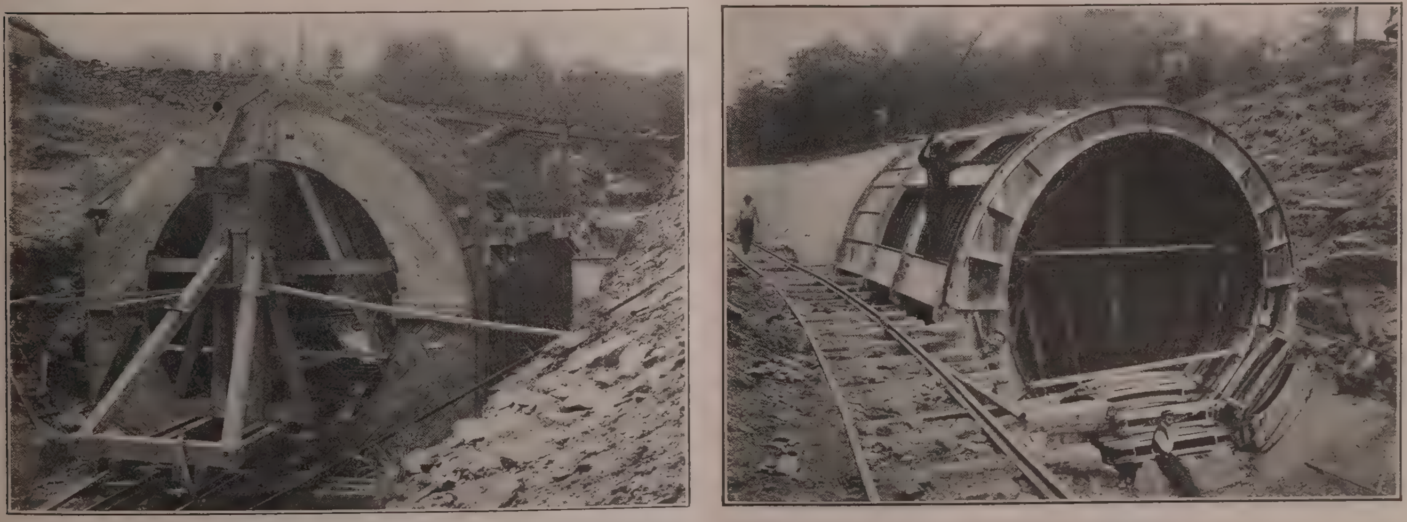
The interior or waterway is circular, while the exterior is a distorted circle tending toward a horseshoe shape. The transverse reinforcing of the effluent aqueduct consists of two rings of $1\frac{3}{8}$-in. square twisted steel rods, the inner ring circular and concentric with the waterway and the outer ring resembling more the outside shape. The pairs of rings are spaced $7\frac{1}{2}$ in. on centers.

In both structures nineteen longitudinal rods of $\frac{1}{2}$-in. square twisted steel are spaced more or less uniformly around the section. In the expansion joints—or contraction joints as they should, perhaps, more properly be called, as it is because of contraction primarily that they exist—a steel plate 6 in. wide and $\frac{1}{2}$ in. thick is placed around the entire section with a diameter 14 in. greater than that of the waterway and with half of the plate incorporated in each of the two adjacent casts.

The design permitted of no longitudinal construction planes by which an invert might be built in advance of the side walls and arch. It was the essence of the design that between vertical bulkheads the section should be built as a monolith and to this end inside forms were required and concrete blocks provided for their support. It was necessary, therefore, to erect inside forms, reinforcing steel and outside forms completely before any concrete was placed and when the latter was begun to carry it to completion in one operation.

FORMS

In the bypass aqueduct Ransome steel telescopic forms were provided for the waterway. Each form was $7\frac{1}{2}$ ft. long and was supported at mid-length by one of the form support blocks. To facilitate collapsing the forms were divided into four parts. Two symmetrical leaves or segments were hinged at the top in the center and two others, each consisting of a half of the bottom third of the circle, were hinged to the bottoms of the side leaves. In telescoping, these bottom segments were folded up and then the two top segments, carrying with them also the bottom leaves, were low-



WOODEN AND STEEL FORMS USED IN BUILDING LARGE AQUEDUCTS NEAR KENSICO RESERVOIR ered and drawn together, the resulting shape passing readily through the expanded forms.

A portion of the inside forms for the effluent aqueduct was of steel, of Blaw manufacture, and was operated like those of the by-pass aqueduct. On a portion of the former structure the superintendent, feeling that the support blocks were likely to prove a source of leakage, built forms of wood that were supported on I-beams which extended through them near the top of the forms. Between the I-beams and the forms were jacks by which the forms could be lowered sufficiently to telescope. The I-beams in their turn were supported at each end on wooden towers, one of which rested on the completed work and the other on the ground in advance of the work. These forms were in 17.5-ft. lengths and consisted of three leaves, the bottom portion of the circle being one leaf of such a size that it could be swung up and clear the I-beam overhead, as shown in one of the photographs.

The outside forms used in this part of the work were also of wood, consisting simply of frames to which lagging could be nailed as needed. The steel outside forms were ribs made of angles or channels, fitted with plates so arranged that part of them were removable. In all cases the outside forms were held in position by the bulkheads and by tapering bolts tying them to the inside forms. The bulkheads were of wood for use with the wooden forms and for the steel forms were built up of angles and plates. Some of the support block forms were of wood and some were built up of steel and presented no difficulties that careful spading did not readily overcome.

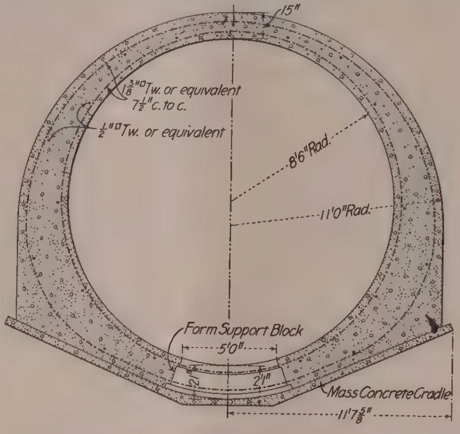
ASSEMBLING RINGS

The mode of procedure was to move an inside form into position, resting it upon its support block, and to thread on it the reinforcing rings that would be needed between that block and the next. With the wooden form only one length was used at a time. The next step was the assembling in position of the rings of steel reinforcement. This was accomplished by the use of three separators. Each separator rested against the inside form and consisted of two pieces of wood, of which one had notches to hold the rings the proper distance apart, and from the form, and the other was plain, being simply bolted to the notched block to form a cover. The three separators were arranged with one at the very top, from which the rods actually hung, and one at each side to keep the rings distended. The rods assembled, the bulkhead was put on and outside forms erected.

Recognizing that the placing of the heavy and awkward rings of reinforcing would occasion severe treatment of the steep slopes and the bottom, entailing the alternative of a disturbed foundation or an extensive excavation of the muck, with the consequent waste of concrete, a concrete cradle was designed and was always built first. This was only 4 in. thick and performed no function at all save to act as an armor for the bottom, thus preserving it from damage. This cradle was placed even in the soft and friable schist encountered. The illustration on the front cover of this issue shows the cradle and the support blocks and forms.

It was quite a trick to bend the heavy rods to such a shape that when suspended they would acquire of their own weight the theoretical shape required, and it was only by experiment that it was accomplished. The rods, from 57 to 65 ft. in length, were bent around a template of such a size and shape that when the rods sprang free and were then hung in the separators they took the true shape, which was quite different from that of the template. Rod-bending machines were tried, but because of the necessity of changing the relative position of the rolls for the different radii required, and because these twisted rods took on when in the machine a sort of spiral shape, the more primitive method of a group of men winding the bar around a template was found in the end to be much the more economical.

In the early work difficulty was experienced with the bulkheads, which in their removal loosened the expansion plates in the joints, and at times even cracked and broke off the concrete. The bulkheads as then built were all of steel and provided with a slot in which half (3 in.) of the plate fitted. This bulkhead wedged tightly and was almost impossible to remove. This difficulty was corrected by leaving this slot in a false wooden bulkhead inside the steel bulkhead. This permitted the steel to be first entirely removed without difficulty or damage and then the wooden bulkhead was taken off with ease when the forms were loosened.



SECTION OF 17-FOOT AQUEDUCT

There arose another difficulty which was soon very successfully solved. This was most marked in the bypass aqueduct, where the diameter of the inside form was less and its curvature therefore the more abrupt. Removable plates had been provided in the outside forms to allow for the working of the concrete through the openings so made. These doors, however, were so arranged that on account of the curvature of the inside form not all parts could be reached properly, even with curved rammers. There resulted zones of improperly worked concrete that exhibited more or less honeycombing. The outside forms were almost entirely rebuilt before any considerable length of aqueduct was constructed, and they were so arranged that two-thirds of the area was removable in small plates, which had the further advantage that they could be handled by one man and by him placed without delay to the hoisting plant.

The greatest difficulty of all occurred in the effluent aqueduct; this was due to the diameter of the inside form being so great. It did not prove feasible to pass the concrete in through the openings of the side forms, although chutes were provided for that purpose, the idea being to get the concrete to go by gravity as near to the center of the invert as possible. The concrete was therefore dumped on the top of the inside forms, which at this point were not covered by the outside forms. Here the difficulty of continually cleaning between the reinforcement led to the adoption of a two-pitched roof, which was removed only when the last of the cast was reached. The eaves of this roof were provided with boards which prevented the concrete from tumbling inside except when wanted, and then only in the quantities desired.

The concrete, in falling, separated; the mortar clung to the circular inside form and the stones fell free, hitting the reinforcing and flying in all directions. Much of the stone landed 10 to 12 ft. from where it was wanted, and it was necessary, therefore, to shovel it over to the center line and there to ram it and spade and poke it back into the mortar. With 1⅜-in. rods spaced 7½ in. on centers this shoveling was done with considerable difficulty, and it was only by the most persistent effort that the stones were again incorporated in the mass of mortar. The men engaged in spading lay upon their backs inside the reinforcing, and it was found absolutely necessary to have the authority of an inspector on each side of the center line until the invert was well completed and the concrete began to rise on the sides.

DIFFICULTY WITH INVERT

A further difficulty that arose sometimes in spite of the utmost care was an invert that was not at all points in contact with the inside or cover form. When the elevation of the bottom of the inside form was reached the fluid concrete had a width of about 12 ft., and because of the large diameter circle it met the cover form at such an acute angle that as the concrete was pushed toward the center it sometimes wedged. In effect dams were formed, one on each side of the center line, and between these dams there was only mortar, which sometimes was insufficient to fill the space. The placing of the concrete at this point was, therefore, a very slow and laborious task. It was necessary practically to suspend delivery for nearly an hour at times in the larger casts, and because of the physical discomfort suffered by the men it was almost impossible to retain those that had been trained to the necessities of the work, even at increased pay. There was practically the equivalent of a new gang each week or ten days.

The lowest longitudinal reinforcing bar was observed to increase the tendency for dams to form and it was therefore moved a few inches to a higher position, a change which helped considerably. Another thing which helped the inspectors very much was to open small telltale holes in the bottom of the inside form; and vigilance was relaxed only when all of these holes vented mortar of the consistency which experience had shown to indicate a condition that would prove satisfactory upon stripping.

The aqueducts were designed and built under the direction of the Board of Water Supply, of which J. Waldo Smith is chief engineer. Frank E. Winsor is department engineer and Wilson Fitch Smith the division engineer in charge of the construction. The contractors are Rinehart & Dennis, of Charlottesville, N. C., for whom P. H. Faulconer is superintendent.

Seros Hydroelectric Development in Spain

Part II—Building 80,000 Horsepower Generating Station with Concrete-Lined Canal System Over 14 Miles in Length in Record Time of Fifteen Months

By J. C. STEVENS
Formerly Project Engineer, Ebro Irrigation & Power Company, Ltd., Now of Portland, Oregon

THE first 11.8 mi. of the power canal have a grade of 0.00015 per cent and a capacity of 2100 sec.-ft. It is concrete-lined throughout. The accompanying illustration shows the section of this canal. It will be noticed that the section approaches the "economic section," i.e., maximum capacity for minimum perimeter and cross-sectional area. This was adopted even at the expense of deep excavation in order to minimize right-of-way and lining costs.

INVERTED SIPHONS

The upper canal for about half its length traverses intensively cultivated lands and a complicated network of irrigation and drainage ditches. In order to pass these ditches small inverted siphons were used. These were made of thin steel pipe with stovepipe joints placed in a trench and surrounded by concrete. At the entrance is a settling basin, concrete-lined, and a grating which prevents floating trash from entering the siphon. In nearly all cases the velocity is sufficiently high to prevent sedimentation. If, however, the siphons silt up, they are readily cleaned by passing through them a cleaning rod made of spring steel bars smoothly joined in lengths of 14 ft. By means of these rods a rope is drawn through the siphon; to it is attached a series of buckets on a chain for removing the silt. Finally a spherical brush is drawn through. In all there are forty-three siphons in the upper canal.

As indicated in the sections, the lining is of concrete 4 in. thick. The gravel in the 1:3:6 mixture is screened to such a size that all particles will pass in any direction through a 2-in. ring.

Attempts were made to place this lining without forms, but the plan was abandoned, as it was found to be impossible to place 4 in. of concrete on a 1:1¼ slope without making it so dry that its impermeability was seriously impaired. The lining was first carried to a vertical height of only 10 ft. in order to allow the made banks to settle as long as possible. The remaining 5.6 ft. were placed after water was in the canal.

Part of the lining was let by contract and part was done by the company. The form boards were placed from the canal side of the 4 x 6-in. uprights. This was advantageous in that the trimmed slope was not touched and hence the green concrete was kept free from dirt that would otherwise be brushed onto it. This system also had the advantage of being more elastic and permitting each side to be lined separately. Thus the lining gang could follow the slope trimmers more closely. The most rapid work, however, was done by company forces using the system shown in one of the illustrations. At first continuous mixers were tried, but they could not compete either in cost or quality of work with hand mixing, and were therefore abandoned.

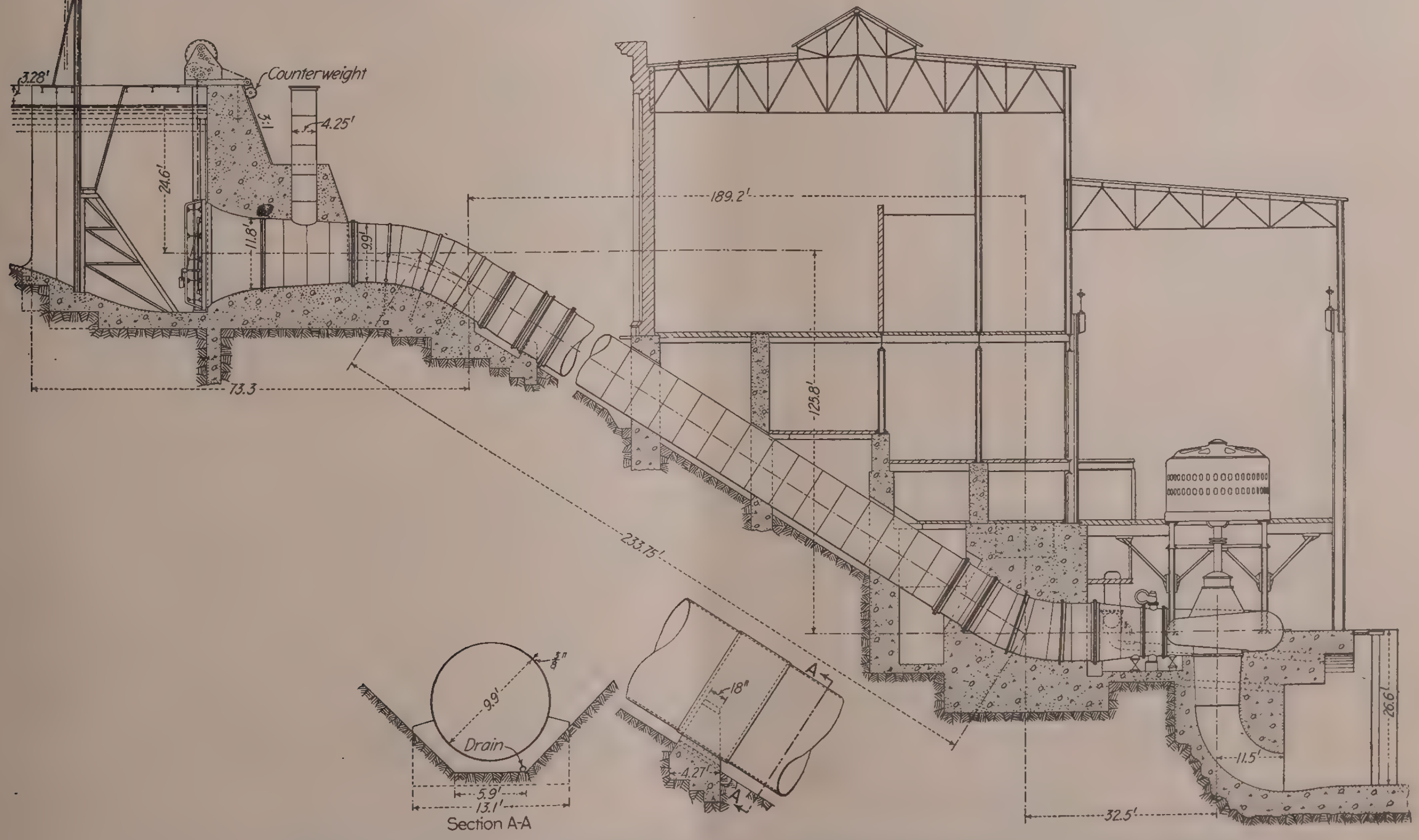
In the design of the canal a coefficient in Kutter's formula of $n = 0.015$ was used for concreted surfaces.

At three nearly equally distant points on the upper canal stoplog structures are provided by which the water in any section may be held if necessary. In each section there are waste gates aggregating 424 sec.-ft. with the canal running full, so that any section may be unwatered. The stoplog structures were built in connection with the arch bridges where the section of the canal was rectangular. Vertical I-beams divide the section into three panels and form grooves into which the stoplogs are let down. The logs are forced down by driving and by jacks. These structures are provisional in nature and served their chief purpose during the testing out of the canal.

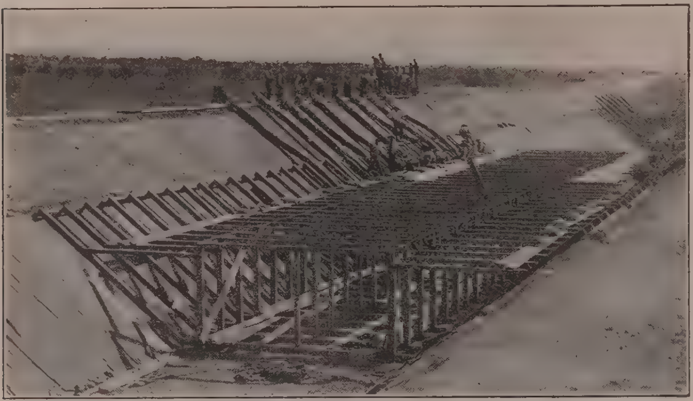
LOWER CANAL

The four reservoirs are connected by a lined canal having a net length, exclusive of reservoirs, of 2.62 mi. and a capacity at low reservoir of 4240 sec.-ft. The canal leads to the penstocks of the power house. The bed of this canal has a grade of 0.00026 per cent, while the top of the embankment is level at an elevation 3.28 ft. above the maximum operating height of water in the upper reservoir. In this manner the head due to fluctuations in the reservoirs is not lost. In designing this canal the velocity head in it was assumed to be lost at the entrance and reproduced anew at the exit of each of the four reservoirs.

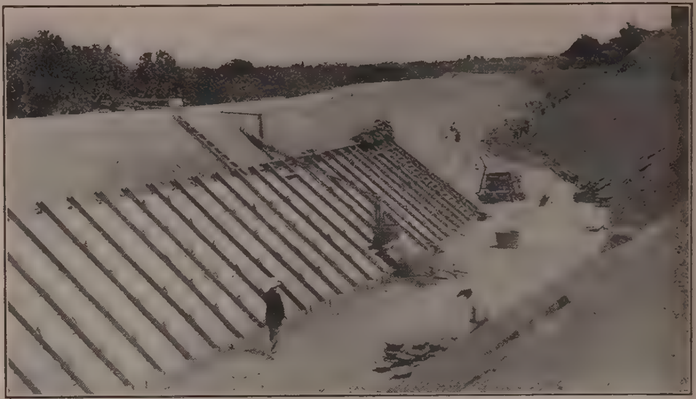
The lower canal is provided with a special stoplog structure at its upper end where it leaves the first reservoir and a set of four waste gates just before entering the forebay. By means of these the storage water may be held in the reservoir and the lower canals and reservoirs emptied, or the water may be passed through the canals and reservoirs and returned to the river without passing through the power house. At this stoplog structure the channel is divided into three portions by two piers provided with grooves for the stoplogs. The logs themselves are



DESIGN OF INTAKE, PENSTOCK AND WHEEL SETTING FOR THE SEROS HYDROELECTRIC PLANT NEAR LERIDES, SPAIN



FORMS USED BY COMPANY FOR LINING UPPER CANAL



METHOD USED BY CONTRACTOR IN LINING UPPER CANAL

made up in leaves 15 x 425 ft. each, of 12-in. timbers, bound with angle bars and fitted with rollers at the ends. Staunching plates project upstream at right angles to the stoplogs and bear against an angle set in the stoplog grooves to prevent the excessive leakage that would otherwise occur.

These stoplogs are suspended in the grooves by cables provided with a trip by means of which they may be dropped instantly. Provisions were made to force the logs down by suspending other logs to channel columns that would bear on the stoplog that had been dropped, but it was found that the momentum the log gained before striking the water was usually sufficient to carry it to its seat. As each leaf weighs 2 tons, a traveling chain block was necessary to handle it. This arrangement is considered temporary and permanent gates will be installed later.

Generating Station

A cross-section through the penstock, turbine and draft tube of unit 3 is shown in the drawing. The power house is provided with four 16,000-hp, vertical Francis turbines direct-connected to 10,000-kw, 50-cycle, three-phase alternators generating at 6000 volts and revolving at 250 r.p.m. Provision is also made for a fifth unit of similar dimensions, to be installed at a later date. The maximum head is 162.5 ft. and the minimum head 151 ft. Excitation is secured by two 600-hp turbines direct-connected to 300-kw generators, revolving at 600 r.p.m. or by an auxiliary motor generator set. Transformation from 6000 to 110,000 volts is effected in the transformer house, which is built as a portion of the power house.

The substructure of the generating station is massive concrete, among the foundations being included the anchor block for the penstocks and the foundations for the turbines. The latter have their draft tubes formed in the solid concrete. The walls of the superstructure and partitions are of brick, which is made near the site. The generator floor, cranes, tracks, roof trusses and inside steelwork are supported by structural-steel columns and the walls. Practically all of the steelwork was furnished by the Blaw Steel Construction Company, of Pittsburgh. The roof is a 3-in. slab of concrete laid on Hy-Rib supported by the steel roof trusses and waterproofed with an asphaltum composition. Some of the floors were also of concrete slab with Hy-Rib and plain round steel rod reinforcing; but the greater portion is of concrete supported by brick arches resting on the I-beam flanges of the floor system. The Spanish masons are very adept at building the brick arches, a single board cut to the span and rise desired sufficing them for centering forms.

The building is provided with an 80-ton Niles crane in the generating room and a similar 20-ton crane over the transformers, as well as the usual machine-shop equipment.

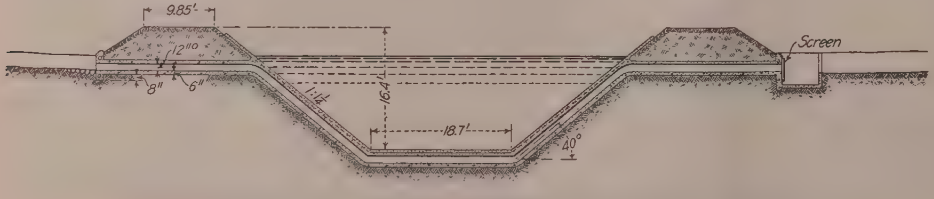
Steel Penstocks

The penstocks for the four main units are of 3/8-in. steel throughout, 9.84 ft. inside diameter, equipped with expansion joints just beyond the upper elbows, which are anchored to the forebay wall. The lower elbows are embedded in an anchor block, which forms a part of the foundations of the generating station. The entrance-reducing section and gate for a fifth penstock are also installed.

The exciter penstock is 3.94 ft. in diameter and is anchored in the same manner as the main penstocks. At the lower end it divides into two branches and supplies water for the two exciter turbines.

Just below the gate each penstock is provided with a vent pipe extending 3.28 ft. above high water in the forebay. The gates to the penstocks are 17.71 ft. square, with two small wickets in each. The gates close by their own weight and are opened by lifting chains without counterweights operated by motor or by hand. The small gates are for filling the penstocks before opening the main gates, and operate automatically. At the lower end of each penstock is a butterfly valve operated by oil pressure.

Before entering the penstocks the water passes a set of screens with bars spaced 1 in. apart. These screens are in duplicate, each being suspended independently by lifting chains running over a chain block, by means of which one screen may be removed for cleaning while the other is in service.



INVERTED SIPHONS FOR PASSING IRRIGATION WATER PAST UPPER CANAL

The turbines and penstocks were furnished by Escher Wyss & Company of Zurich, Switzerland; the gates and gate mechanism, by Ransomes Rapier, Ltd., of London; the racks and screens, by Amme, Giesecke & Konegen, of Braunschweig, and the electrical equipment, by the General Electric Company, of Schenectady, N. Y.

Repairing Breaks in Lining

The filling of the canal and reservoirs was accomplished with no serious consequences. Settlement of the earth banks of course could not be avoided, and on account of the comparatively thin lining it was necessary that the water should be raised slowly in order that the effect of this settlement could be observed and any needed repairs made at once. It was observed on some of the higher embankments that the earth settled inward toward the canal, the first evidence being a crack between the lining and the embankment. As fast as these cracks opened, drill holes were made behind the lining with long drills at intervals of about 18 in. and an almost liquid puddle of clay and water was poured into them. In this manner the support for the lining was maintained and the lining preserved intact. As soon as the bank had taken its settlement no further difficulty was experienced. Very little lining was broken by settlement, and wherever breaks did occur they could nearly always be traced to poor contact between the upper and lower strips of lining.

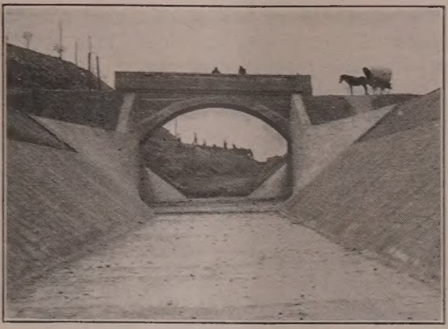
In spite of eternal vigilance and inspection, the placing of the upper strip of lining was in a few places begun before the old surface had been properly squared and cleaned, with the result that when settlement occurred the upper strip of lining was taken with the earth, breaking or cracking at the joint. Repairs of this joint were necessary in about 650 ft. of its length, which is very little considering that this joint was about 148,000 ft. long. Wherever the joint was properly squared and cleaned the lining remained intact and the bank settled free from the lining. The space thus opened was filled with puddle, as previously described. In all, not more than 6500 ft. of embankment required treatment of that kind.

Filling of Reservoirs

The filling of the reservoirs was attended with some settlement and consequent cracking of the earth dams. The seepage for each was carefully collected and measured over Cippoletti weirs, readings being taken every 2 hr. The total seepage from all of the seven dams did not exceed 3 sec.-ft. with full reservoirs. The seepage increased uniformly with the head, but whenever the head remained stationary there was noticed a tendency to decrease. Little or no seepage occurred through the dams themselves, but nearly all of it occurred in the horizontal strata of porous rocks that are exposed in the side of the canyons. Seepage through these original hillsides could not be prevented. In some cases the seepage appeared below the dam, in some it came to the surface within the section of the dam near the back. Where this occurred deep trenches were dug into the hillside, following the toe of the embankment with spurs where necessary to intercept the water. These trenches gave an easier outlet for the water and prevented saturation of the earth embankment. They were refilled with large, broken stone of a uniform size to prevent caving. The rock dikes answered the purpose of a blind drain, and in nearly all cases water began to weep from them after the reservoirs were filled. The greatest seepage occurred from dam 1. A spring of crystal-clear water developed from the outlet of the rock dike, running about 80 gal. per minute with the reservoir full. This water undoubtedly comes from the canyon side and follows the rock dike to its outlet at the lowest point of the valley. The remainder of the seepage, except for a small portion that appears as ground seepage in the valley below the dam, comes from the horizontal rock strata in the canyon sides. A trench was dug along the entire length of the toe of this dam and all saturation of the body of the dam was effectively prevented in this manner. The total seepage from the dam is 1.05 sec.-ft.

Transverse settlement cracks developed along the shoulders of the embankment on all dams. These cracks continued to widen from a hair crack to about 1½ in. in width in some cases. They were sealed by drilling 3-in. holes along the crack and refilling with a liquid clay puddle.

Dam 3, which will take its place among the high earth dams of the world, showed very little settlement and comparatively little seepage. The total seepage with reservoir full was 0.64 sec.-ft., all of it coming from the rock strata in the original hillsides.



TYPICAL BRIDGE FOR HIGHWAY CROSSING

It is almost impossible to build an earth dam that will not leak, and as long as the seepage water remains clear there is nothing to be feared. To have completed seven earth dams on one project in which the combined leakage is less than 3 sec.-ft., or 1 part in 1400 of the flow from the reservoirs, is a source of no little satisfaction to the writer.

RAPID CONSTRUCTION

The entire project was built very quickly. Active work was begun in January, 1913. Water reached the forebay on March 10, 1914, or fifteen months later. The construction of the project involved the following quantities: Right-of-way, 1800 acres; excavation exclusive of borrow pits for dams, 2,540,000 cu. yd.; embankment in dams, 1,065,000 cu. yd.; structural steel, 2110 tons, and concrete and masonry, 167,800 cu. yd.

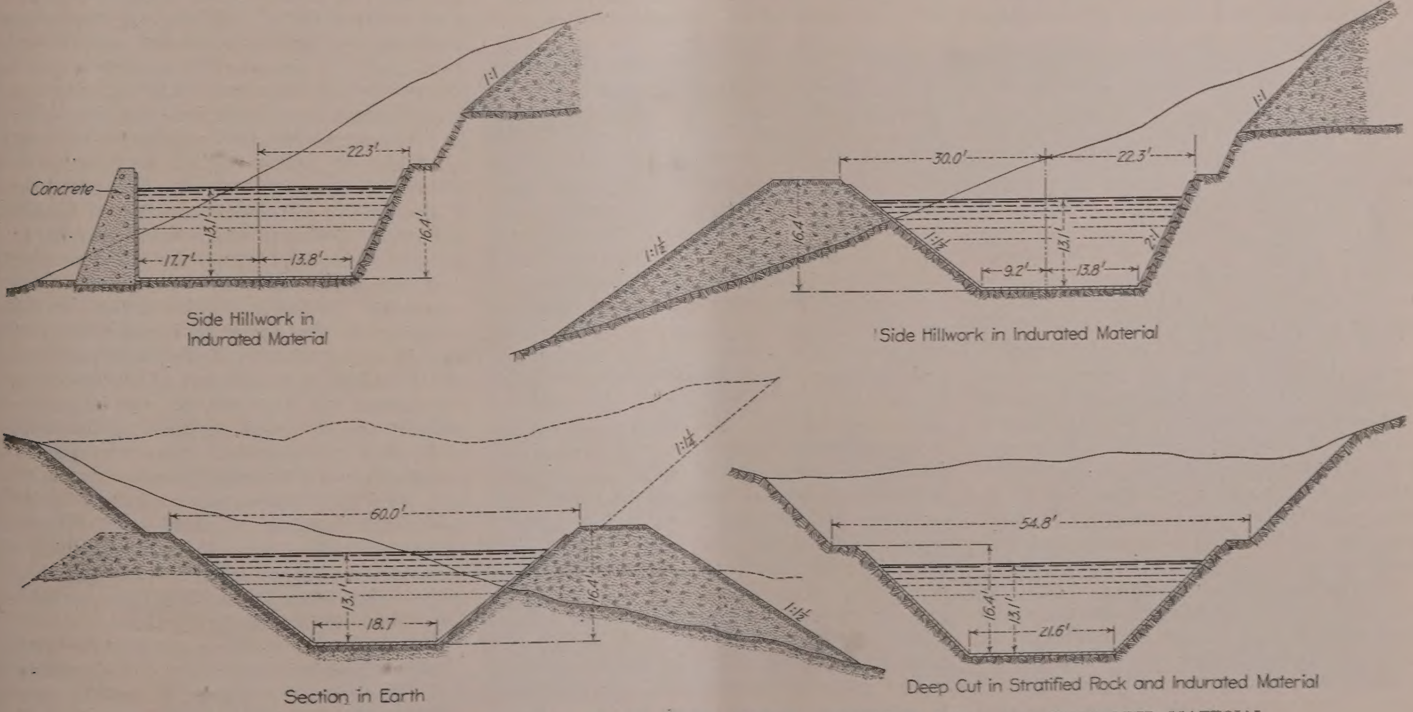
The work was carried out by the Ebro Irrigation & Power Company, Ltd., of Barcelona, Spain, under the supervision of the Pearson Engineering Corporation, Ltd., of New York. The following are the officials in charge of the work: F. S. Pearson, Dr. Sc., M. Am. Soc. C. E., president; A. W. K. Billings, M. Am. Soc. C. E., vice-president and managing director; Fred W. Abbot, M. Am. Soc. C. E., manager of construction; J. A. Sargent, Assoc. M. Am. Soc. C. E., chief engineer. The work was executed under the inspection of the Public Works Department of Spain; Don José Bores was chief engineer for the Provence of Lerida.

Important Details in South American Trade

IN the substantial increase in trade with South America which the immediate future promises it is highly desirable, according to a recent consular report, that American manufacturers should keep clearly in mind some of the cardinal points of difference between South American trade usages and those of this country. The social feature, almost negligible in the United States, is an important factor in trade relations in Latin America. Traveling salesmen will find that they will make more progress by taking their time in working up a personal acquaintance with the trade than by attempting to close a sale on the first visit; and a courteous letter, written in Spanish and directed especially to the person or firm addressed, in contrast to a circular or form letter, will probably prove far more valuable as an accompaniment of a catalog and price list than the mere catalog itself.

In many ports of South America, all goods have to be lightered to shore, and on landing are sometimes allowed to remain exposed to the weather for several days. The necessity for strong boxes and crates, well reinforced, is obvious. An unfair practice which is sometimes resorted to and which is particularly irritating to buyers is the substitution of one type of goods for another which has been specified in the order.

Americans sell for cash, or on a credit of one to three months; Europeans allow three to nine months, or even longer. Perhaps the best of all mediums for keeping in touch with the credit situation is the permanently established American branch house or agency, with Americans of experience in charge. A firm with such a representative can afford to grant credit terms.



Side Hillwork in Indurated Material

Side Hillwork in Indurated Material

Section in Earth

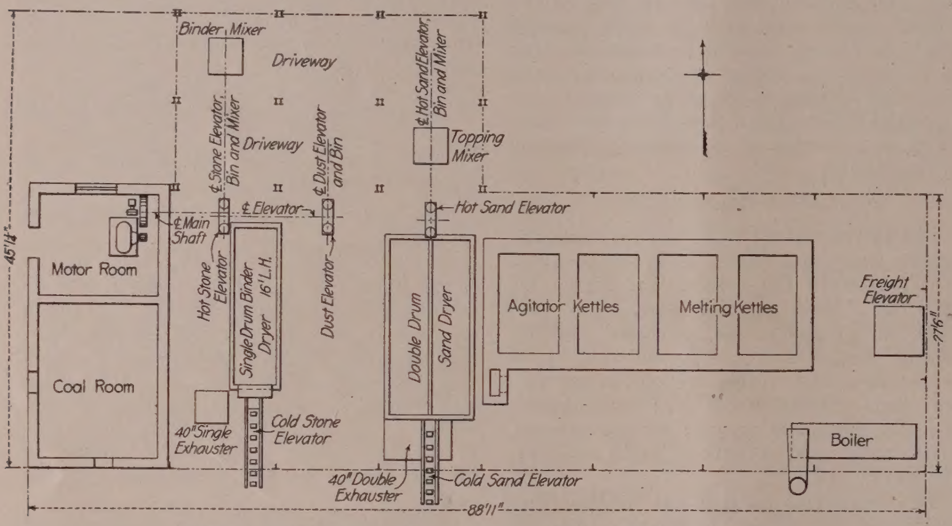
Deep Cut in Stratified Rock and Indurated Material

TYPICAL CROSS-SECTIONS OF CANAL FOR SIDEHILL WORK, EARTH, STRATIFIED ROCK AND INDURATED MATERIAL

Chicago's Municipal Asphalt Plant

Superintendent of Streets Calls Attention to Gradual Improving of Repair Organization Since Rejection of Contract System

SUCCESS, spelled by a 45 per cent reduction in unit costs and greatly increased efficiency in conducting the work, is claimed for the system of asphalt repairs by city forces, started in 1912 by the Chicago street department. The desire to eliminate the waste of time due to dealing with the contractor—advertising, estimating, letting contracts and making payments —and the realization that the new step meant merely adding a field force to that engaged in keeping records of yardage and cost were the chief factors influencing the change. Walter G. Leininger, superintendent of the bureau of streets, has furnished information concerning the organization of the new force in 1912, the building of a city plant in 1913 and data of the work accomplished.



GROUND PLAN OF CHICAGO'S MUNICIPAL ASPHALT PLANT

The first attempt by the bureau in 1912 to repair streets out of reserve was done by contracting for material at the plant of a contractor by the ton. Hauling and laying were done by the city forces, and although the cost of material was high the results were pleasing and the work was of a high standard. There were 2,059,000 sq. yd. of asphalt which had passed the guarantee period. The city forces maintained this area, repairing 76,488 sq. yd., for $105,160.52. The unit repair cost was therefore $1375, and the unit maintenance cost, 5.1 cents. A fair average for maintenance done previously by contract was 6 cents per square yard.

The new plant, which was intended to allow greater freedom in experimenting, was ready for the next season. A central location—Fifteenth Place, between Loomis Street and Ashland Avenue—was chosen and a structure 89 x 45 ft. was built. The building is between two elevated steam railroads whose tracks are on walls 17 ft. high, affording ideal side trackage for handling materials.

The accompanying drawing shows the layout. A sewer directly through the street takes care of all drainage of roadways and pits. All storage tanks are placed underground where practical and incased in concrete. The plant is electrically operated and lighted.

The plant can be utilized for the manufacture of top, binder or bituminous mixture, and has a rated capacity of 2000 sq. yd. of finished pavement per day of 8 hr. By finished pavement is meant 2 in. of top and 2 in. of binder. It turns out all asphaltic filler required for brick and granite-block repair, as well as the liquid asphalt used for building macadam streets by the penetration method. Trinidad Lake and Cuban natural asphalts, as well as blown-oil products, are being used at present.

The total capacity of the sand and stone storage bins is approximately 850 cu. yd. Cement is kept in a brick-lined room, which is air and water tight. Five hundred barrels of cement are kept in readiness for use. From the storage bins the material is carried by conveyors to the hoppers at the top of the plant. From these hoppers it is fed to the different mixers as required. After mixing it is conveyed to the wagon and arrives on the job at from 280 to 320 deg. Fahr.

Each wagon is loaded in approximately 10 min., and top and binder can be loaded at the same time, there being two mixers. This year the department purchased twenty 3-yd. asphalt wagons. When other wagons are needed they are hired by the day. The city owns no horses. The largest number of asphalt wagons working this year was sixty, and the number varies a great deal from time to time, depending on the length of the haul. Hauling of material will be greatly improved and cheapened in the near future, as the bureau has purchased two 5-ton dump trucks to assist in the long hauls. It is estimated that each truck will take the place of three and one-half teams.

The plant proper was built by Hetherington & Berner, of Indianapolis, for $46,000. The addition of an office, scale house, chemical laboratory and baths has brought the expenditure to about $75,000. The operating force numbers twenty-nine—a plant foreman, a foreman of drum men, two drum men, three kettle men, a mixer man, fifteen laborers, a chemist and an assistant, two samplers and two watchmen. Each street-repair gang—there are from two to five, depending on the season—is made up of forty-four men—a foreman of asphalt repairs, a foreman of cutouts, three rakers, three smoothers, three tampers, thirty helpers, one rollerman and two watchmen.

The proposed repair work for the year is laid out on a small map by the general foreman in charge. Care is taken to district this work in a manner that will require the shortest moves, and a system of streets is repaired in one location before moving on to the next. The first move made on the arrival of the gang on a street is to mark out the cuts to be made and the holes to be repaired. This is done by the foreman of cutouts, and passed on by the general foreman. As fast as the cuts are made and trimmed the old material is gathered up and taken away. The painting of the edges with asphaltic cement is next completed. The binder gang then follows, bringing up the repair to within 1½ to 2 in. of the top. The binder is tamped and smoothed, ready for the top, which is then laid, raked, smoothed and ironed. After rolling with a 5 or 8-ton roller the surface is dusted with cement and barricaded with wooden horses until the street is ready for traffic.

A record of all asphalt streets in the city, as well as those of other materials, is kept by map and card index. All streets under the contractor's reserve are placed on the map in a colored dotted line, which, as soon as a street falls to the city to maintain, is made solid. All dimensions and data are filed alphabetically in a card-index file, and on the reverse side of each card a complete record of repair is kept, showing yardage repaired, cost, etc. In order that the superintendent of streets may keep in constant touch with the various repair gangs, a map with colored thumbtacks showing the location of each gang is kept. A location report is sent to the office of the bureau each night by the various foremen, and the plat is kept to date from these. The location of road rollers is noted by the same method, and in this way the shortest moves for the machines can be planned by the assistant superintendent in charge of repairs.

The plant is operated on the following basis: A capital-account credit of $75,000 is placed at its disposal, allowing the purchase of supplies for the season's work. Each of the thirty-five wards in the city is credited with a per cent of the vehicle-tax fund based on the amount of collection. When the plant is furnishing material for any ward it charges a price per ton sufficient to allow for all overhead expenses plus depreciation. These prices are much lower than could be procured by contract. The charge for top mixture is $7.50 per ton; for binder, $4.50, and for bituminous macadam, $5. The actual cost to the plant for topping is $5.75; for binder, $3.75, and for bituminous macadam, $4. During the operation of the plant an average earning of $4,000 per month is shown, which holds the capital account stable and allows for all depreciation, repairs and the like.

In 1913, in spite of the difficulties of breaking in the force and handling new machinery, 3,547,600 of the 4,309,200 sq. yd. of asphalt pavement out of reserve were maintained for $119,828.63. Of this area 147,638 sq. yd. were repaired. The unit costs were therefore 81 cents for repairs and 3.38 cents for maintenance. It will be seen that the maintenance charge under the contract system—6 cents—was reduced 45 per cent in 1913. Because of the increased competence of the force and the more complete equipment Mr. Leininger expects even better results for 1914.

At present resurfacing old granite-block pavement and brick pavement is being carefully studied. The bureau is looking forward to the construction of another plant when expansion warrants it.

Letters to the Editor

Incentives That Help Men to Work

SIR: We are fast getting away from the notion that slave driving or even piece rates are the only incentives that will add to production, and are seeing that there are some higher considerations. Work has been defined as something which one does at a time when he would not do it if he did not have to, and play as possibly the same thing, done when one wishes to do it. The ideal condition would be one in which everybody found something to play at which would serve a sufficiently useful purpose to satisfy his material needs and a fair share of his imaginary ones.

Our Socialist friends have an idea that if we lived on a communistic basis all positions of responsibility would be filled by men who preferred doing administrative work, without extra pay, to doing routine work. I fear that we have not found enough of the play element in executive work to make it come out that way. I am very sure that further down the line we have developed a division of labor that eliminates the play element entirely.

A man who is tending a semi-automatic machine, where there is nothing left for him to do except to feed stock into it, becomes a part of a machine and about as capable of enjoying his work as the gears and shafts which do the rest of the job. Such a man gets his satisfaction in life out of his pay envelope and what it will bring him. This seems like a low aim, but it is one that modern systems of manufacture have forced upon us, and one which will stay because it is advantageous in so many ways to all concerned. We cannot and we do not want to go back to the time when we made machinery bit by bit, and when we wound each wire into a generator without regard to its replacement. It might make the work more attractive, but the men who could do that work are already occupied with better jobs. The men who do the bulk of the work under the present system of minute subdivision of labor are men who could not be educated up to the point of doing the work at all under any scheme which left any pleasure in its doing. We must face the fact that money is solely a medium of exchange. Even if the work we can offer certain types of men does not in itself afford a reasonable amount of joy, the money we pay for it can be exchanged for whatever kind of pleasure the recipient sees fit to enjoy.

A shop must be organized as the exact antithesis of a farm. There a man plows when he feels like it. He has a large range of time within which to plant. He may cultivate to-day or wait till next week, and he harvests and markets when the spirit and the market prompt. If he gets up at 4 a. m., which he does not do except to catch a train, outside of fiction, he can do it because he went to bed at 7. With the artist, he represents almost the only type of man that gets any considerable joy in the creation of things as a complete whole. The man who spends day after day and week after week drilling lugs in a jig cannot be blamed if he watches the clock.

The real incentive for these men is money, and there is nothing that will take its place. Give a workman a quarter a day more than he knows he can get elsewhere and he has as keen an interest in the welfare of the company as any profit-sharing scheme can give him. Men who draw day wages can appreciate a few cents a day as much as the superintendent can dollars. If the superintendent does not realize this let him imagine for a moment that his savings have been wiped out and his income reduced to that of the man whose case he is considering, and he will see how important those few cents are. He will realize how it is that men leave shops where the surroundings are good and everything is just to their liking except just a little money.

Worcester, Mass. E. H. FISH.

[Comment on this letter will be found in the editorial pages of this issue.—EDITOR.]

Cloudburst at Telluride

SIR: Hydraulic sluicing methods were resorted to at Telluride, Colo., to clear the city's streets of débris which had been deposited to depths of from 4 to 10 ft. following a cloudburst on July 27. The flood of water and mud which poured out of Cornet Creek canyon covered about fifteen blocks in the central business and residential section.

Immediately following the storm, a committee laid plans for cleaning the town. A flume was constructed through the inundated section, and by the aid of the water from Cornet Creek and the local water system the accumulation of mud was sluiced to the San Miguel River. It will be several weeks before the tremendous volume of mud and débris can be removed.

T. K. ROBERTS.

FLUME FOR WASTE MATERIAL

DISLODGING DÉBRIS FROM STREETS IN TELLURIDE AFTER CLOUDBURST

Should Stairway Capacity Be Determined by Character of Construction or of Occupancy?

SIR: Within thirty days the writer expects to take up the revision of the stairway sections of the Cleveland building code. After examining the codes of a number of other cities, it would seem that code writers in the past have worked on the assumption that stairways should be varied in capacity and number according to the fireproofness of the building in which they are located, and have given very little attention to the question of occupancy as affecting stairway requirements.

It seems to the writer that this method of treating the subject is entirely irrational, for the reason that the most fireproof building that can be constructed would have within it combustible materials in sufficient quantity which, if they were burned up, would create enough heat to suffocate the occupants. Very few persons are actually burned to death. They are overcome by the products of combustion before actual contact of the flames with their bodies takes place. It is therefore my intention to arrange stairways with regard to the grades of occupancy of the building rather than the class of construction.

It is obvious that different grades of occupancy should be treated differently in the matter of the number and width of stairways. For example, a cold-storage plant of 5000-sq. ft. floor area would probably never have more than two persons on any one floor at the same time. This would mean that 2500 sq. ft. of floor area per person would be ample for calculating the required stairways, whereas in the case of assembly halls it is not uncommon to have persons as close as they can stand, which means one person for every 2 or 3 sq. ft. No one would urge that the stairways which would be adequate for a cold-storage plant would be sufficient for an assembly hall, or vice versa, and yet both of these buildings might be of fireproof construction.

In order to get all possible assistance in connection with this study, I am sending you herewith a list of grades of occupancy of buildings which are most common. I would be pleased to have your readers send me their views as to the proper number of square feet to allow per person for each grade of occupancy in arriving at the number of persons for whom stairways should be provided, this table to be used when the number of persons occupying the building is not definitely known. If there are any grades of occupancy not included in this list which your readers think deserve special consideration, I trust they will suggest the same, together with their views as to how they should be treated.

The results found by a survey of actual conditions are better than theory. The grades of occupancy under consideration are as follows:

1. Warehouses
2. Workshops
3. Factories
4. Department Stores
5. Mercantile Buildings and Stores
6. Garages
7. Tenements
8. Lodging Houses
9. Hotels
10. Club Houses
11. Office Buildings
12. Cold Storage
13. Gymnasiums
14. Museums and Art Galleries
15. Skating Rinks

Theaters and assembly halls are covered by the State code and cannot be changed by act of the City Council. For this reason they are omitted from this list.

An early and full discussion either directly or through your columns will be much appreciated.

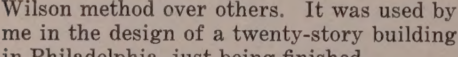
V. D. Allen,
Cleveland. Commissioner of Buildings.

Formulæ for Wind Stresses

Sir: In reading the interesting paper, "Formulæ for Wind Stresses," by David Gutman, in your issue of August 22, page 213, the writer was glad to see credit given to an article by A. C. Wilson in the Engineering Record of Sept. 5, 1908, page 272. At present probably more high buildings are having the wind bracing designed in accordance with this method than any other. More than once the writer has asked an engineer how he figured wind bracing, and he has answered by pulling out a well-worn copy of Wilson's article, "Windbracing with Kneebraces or Gussets," clipped from the Engineering Record.

Referring to the close of Mr. Gutman's paper, where he quotes from an article of mine some criticisms of the Wilson method, I will advise that further on in the same article will be found my preference for the Wilson method over others. It was used by me in the design of a twenty-story building in Philadelphia, just being finished.

In an eighteen-story building elsewhere, the wind bracing was designed in accordance with what may be called the portal method. In a transverse bent the columns are turned thus:



The beams or girders between columns are considered a series of independent portals, the connection at each end taking the same amount of resistance. The direct stress from overturning due to wind is taken entirely by the outer columns; the horizontal shear in each outer column is one-half that of an inner column; the bending moment of an outer column is one-half that of an inner column, and the bending moments due to wind for all girders on the same floor are alike. When the columns are turned as shown this is an ideal method for the detailer and the shop.

In this connection attention is called to the article in your issue of Aug. 15 describing the wind bracing of the Adams Express Building, in which the portal method is used.

R. Fleming,
Designing Engineer, American Bridge Company.
New York.

Pocket Level for Short Distances

Sir: The description by Thomas C. Harris of a pocket level for short distances, on page 200 of the Engineering Record of Aug. 15, contains the following statement: "The writer designed the device, which is not patented." In 1892 I obtained a patent on a level to be used for the same purpose and intended to be used on a tape or on a cord. The patent application had to be amended to omit the use of the level on a cord by suspension as in the device illustrated by Mr. Harris and clamps were substituted so the level could be applied to tapes only. The hanging level to be used on a cord had been patented several generations earlier. My tape level had a very good sale, but as the patent has expired the manufacture is open to any one, and for several years the sale has not been pushed. Levels such as that illustrated by Mr. Harris have been on sale for years in hardware stores and are advertised in building papers. Many carpenters carry them.

Chicago. Ernest McCullough.

Committee Collects Road Data

Sir: I am forwarding to you a new data form recently compiled by the special committee of the American Society of Civil Engineers on "Materials for Road Construction and Standards for Their Test and Use." It is the intention of the committee to distribute these forms to engineers having charge of bituminous surfaces and bituminous pavements. The accumulation of the data supplied by highway engineers will be of great value to the committee in connection with drafting conclusions as to many fundamental details of construction and maintenance.

A. H. Blanchard,
New York City. Secretary.

[The blank forms referred to are reprinted below.—Editor.]

AVERAGE DAILY TRAFFIC AS DETERMINED BY CENSUS

Taken for......Hours on Following Dates..........................

	Commercial		Passenger or Pleasure	
	Empty	Loaded		
One-horse vehicles				
Two or three-horse vehicles........				
Four or more horse vehicles........				
....				
Motor cycles......................				
" runabouts................				
" touring cars (open or closed).				
" buses....................				
" trucks...................				

Are widths of tires on horse-drawn vehicles regulated by law or ordinance?
If so, please state regulations on separate sheet.
If no traffic census is available, give estimate of traffic.
....
Total cost of bituminous surface or pavement, $..........
Cost per square yard, $..........Average thickness, in inches..........
Average wages per day, of common labor, $..........Working day of ....hours.
Description of Bituminous Material used.
(State type, trade name, company purchased from, and if supplied by contractor or otherwise.)
(If analysis is available, please attach copy of same.)

Remarks: (Including notes as to speed, tire widths, and any preponderance of traffic at certain hours.)

Name..................................
Title..................................
Address................................
....
....
Date..............191.... *Reporting Officer.*

THE GLENWOOD BRIDGE of the Pittsburgh Railway Company over the Baltimore & Ohio Railroad tracks, Pittsburgh, was required to be replaced by a new structure on the same site without more than three days' interruption of traffic. This was accomplished by erecting the new trusses separately on temporary falsework at one side of the old span, moving them out to proper relative position on falsework extensions of the abutments, assembling the floor system between them, completing the new structure, dismantling the old structure, removing it and hauling the new one transversely to permanent position. The work was described in a paper entitled "Principles and Details Involved in Moving Large Structures," presented to the Engineers' Society of Western Pennsylvania by G. W. Nichols, chief engineer for the John Eichleay, Jr., Company, of Pittsburgh, who executed the work. The new truss span, 100 ft. long and weighing 200 tons, has all of the steel construction incased in concrete up to the floor line. Sidewalk brackets were first removed from one side of the old span and the abutments extended by falsework on the same side to receive the new span. Midway between them a falsework bent was erected parallel to them between the railroad tracks to support two pairs of 20-in. I-beams 60 ft. long. These were extended to the tops of the banks and supported a temporary track on which the 20-ton trusses were assembled.

DATA CONCERNING THE USE OF BITUMINOUS MATERIALS IN SURFACES AND PAVEMENTS

General Information

State..................................County..................................
Town or City..................................Highway..................................
Contractor..
Length of Work..................................Width of Metal (Average)..................................
Date of Beginning..................Date of Completion..........................(of use of Bituminous Materials)
Method of Construction (state character of foundation, thickness of courses, kinds and quantities of road metal and of bituminous materials used, methods used, and approximate maximum grades).
(Attach copy of specifications if available.)